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Potential System Integration of Existing Airport Security Equipment

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by
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Since the accepted measures in the industry are imperial, metric measures are not used in this report.

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16. Abstract

The objectives of this study were to:

- understand security screening equipment and configuration currently being used by North American airports;
- develop a concept for equipment consolidation and integration;
- propose a methodology to achieve this consolidation in order to improve the overall efficiency of the security screening process.

To prepare for any airport security system integration initiatives, this report presents the overall perception of integration initiatives by manufacturers and airport staff (including security personnel); indicates the types of opportunities and constraints associated with implementation; and presents a list of the most favourable integration candidates.

To determine the implications, importance, constraints and benefits of integrating airport security equipment, a number of interviews were conducted in Canadian and U.S. airports. Interviews with manufacturers of airport security equipment were also conducted to assess the integration capability and technical constraints of various components.

In conclusion, it is evident that the challenges presented by security equipment integration outweigh the benefits. When evaluated against other initiatives such as scanner training, the required effort and resources appear to be better placed in other pursuits. The implications of these findings may be helpful in setting priorities and agendas, in addition to serving as background material for future research, or in advance of preparing an implementation plan.

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16. Résumé

Objectifs de l'étude :

- faire l'inventaire des matériels de filtrage de sûreté, et de leurs configurations, actuellement en usage dans les aéroports nord-américains;
- élaborer un modèle de rationalisation et d'intégration des matériels;
- proposer une méthode pour réaliser cette rationalisation et accroître ainsi l'efficacité du processus global de filtrage de sûreté.

Dans la perspective d'une intégration éventuelle des matériels de sûreté aéroportuaire, ce rapport présente les points de vue des fabricants et des employés des aéroports (y compris des préposés à la sécurité) sur des projets d'intégration, expose les possibilités et les contraintes associées à une intégration, et donne la liste des technologies se prêtant le mieux à l'intégration.

Pour déterminer les incidences, les contraintes et les avantages pouvant découler de l'intégration des matériels de sûreté aéroportuaire, et l'importance d'une telle intégration, les chercheurs ont réalisé des entrevues dans des aéroports canadiens et américains. Ils ont également rencontré des fabricants de matériels, afin d'évaluer l'aptitude à l'intégration des divers systèmes, et les contraintes techniques qu'ils posent.

En conclusion, il ressort clairement que les obstacles posés par l'intégration des matériels de sûreté l'emportent sur les avantages. Il semble que les ressources et les efforts que nécessiterait cette intégration seraient mieux investis s'ils étaient dirigés vers d'autres projets, comme la formation des préposés au contrôle de sûreté. Les conclusions de la présente étude pourront être utiles au moment d'établir les priorités et les programmes. Elle pourront aussi servir de toile de fond à des recherches futures ou de données préliminaires pour la préparation d'un plan de mise en oeuvre.

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Executive Summary

The objectives of this study were as follows:

- to understand security screening equipment and configurations currently being used by North American airports;
- to develop a concept for equipment consolidation and integration;
- to propose a methodology to achieve this consolidation in order to improve the overall efficiency of the security screening process.

Comprehensive interviews of security equipment manufacturers, aviation organizations, airport security officers and other resources were conducted to gain an understanding of current security environment and technology. Security equipment with the most potential for integration was then examined. Integration candidates were divided into two groups: existing technologies currently employed in airports (*base* candidates) and emerging, innovative technologies (*expanded* candidates). Following an evaluation of existing technologies, integration scenarios of the base candidates were analyzed. Expanded integration candidates were then considered and integration scenarios employing these innovative technologies were developed.

To address the third objective, consideration was given to the overall security screening process and how best to implement integrated systems. The potential for integrating airport security equipment, and the implications associated with various options were assessed. While several potential candidates were identified, the crucial task was to determine which were the most viable and beneficial from a technological, process and human factors perspective. In applying a set of key criteria to potential candidates, a set of scenarios was developed that involved existing equipment as well as technology and processes not consistently employed in an airport environment.

Three principal criteria were used to assess equipment integration technology: the ability to expedite passenger processing, the likelihood of improving detection, and the ability to reduce the number of false positives in the screening process. This exercise provided a sense of the "real" implications of applying innovative, integrated technologies to airport security and the likely effects on passengers, security officers and overall operations.

From the interviews conducted, it became quickly apparent that an initiative to integrate airport security equipment would not be widely supported, at least not in isolation. Equipment integration was not accepted as a being a high-priority pursuit, particularly when measured against a number of other initiatives, including: increasing the level of training required for screeners; employing innovative technologies to improve detection; streamlining the overall security process to increase passenger throughput; and other initiatives. Notwithstanding this assessment, the integration of airport security equipment has the potential to aid in improving overall detection, as described in the body of this report.

Principal Observations and Conclusions

As with the analysis of potential and most favourable integration candidates, observations and conclusions are grouped into three categories: people, process and technology.

People (Human Factors)

- **Integration is not expected to reduce the number of personnel** required at security checkpoints because:
  - high alarm rates necessitate the frequent physical inspection and manual screening of passengers and carry-on items;
  - effective X-ray equipment use requires that bags be spaced apart and positioned to maximize image size and eliminate jamming;
  - sufficient personnel are needed to ensure that suspect passengers can be quickly apprehended with minimal disruption to the continued processing of following passengers;
  - despite clear signage at primary inspection points, passengers routinely neglect to remove metal objects from their clothes, purses, bags, etc., requiring security officer intervention.

- **Screeners would be required to operate integrated explosive detection devices** and to physically inspect suspect items and passengers. It is expected that explosives detection devices will yield a high rate of false alarms because of the number of innocuous items that may cause alarms (for example, some heart medications).

- **Security officer training needs to be consistent and thorough**. Many stakeholders interviewed believe that this is a substantial area of risk. During airport inspections, instances were observed where screeners were distracted and unsure of how to proceed while processing high passenger volumes. Insufficient training and lower wages were cited as contributors, but layout, staffing levels and equipment utilization were also issues.

Process (Passenger and Baggage Screening)

- **Integration with passenger identification systems** could be used in conjunction with an expert system to select certain passengers for in-depth screening at a central location. For example, all the X-ray images of passengers' carry-on and checked baggage could be inspected at a central screening point and, if necessary, the passenger could be apprehended at the boarding gate (e.g., Computer-Assisted Passenger Screening).

- **Integration would provide the opportunity to gather statistical data on the frequency of alarms and on explosive detector measurements**. Along with written records kept by screeners documenting the results of secondary screenings, this data could be used to optimize explosive detector performance through selection of an optimal detection threshold. This could also be applied to metal detection.

- **Manual inspection of X-ray images of checked bags, combined with passenger information** (obtained from bar-code/RF tag on bag), could be used to further divert checked bags for manual inspection. By integrating the checked baggage system with the passenger security checkpoint and departure gate, screeners at those locations could be alerted, thus streamlining the process of apprehending passengers.

- **Incorporating queue management staff would increase throughput significantly**. It was observed that the number of passengers entering incorrect screening areas or check-in counters was noticeably reduced when staff members were available to help passengers in the queues. Assistance was as simple as confirming a passenger's destination and documentation.

- **Not all individuals passing through security are passengers**. At most airports in the U.S., members of the public are allowed to pass through security. "Meeters and greeters" are not subject to boarding pass checks, as are passengers. Only metal detection and X-ray and/or manual search of any hand-held baggage are required for individuals who are not passengers.

Technology (Integration)

- **Integration of detection systems with a passenger identification system** could enable a complete profile of each passenger to be logged and archived, for any of a range of profiling initiatives. The passenger identification system could contain information such as flight number, airline and destination.

- **To be useful, integration would need to include identification capabilities for both passengers and objects**. Two options were identified:
  - Boarding passes and all items could be tagged with bar codes at check-in. At security checkpoints, bar codes would be scanned and airline systems queried to establish passenger information (for example, name, flight number, departure gate, departure time, destination).
  - Boarding passes and all items could be tagged with radio frequency tags at check-in. The RF tags would be used in the same way as bar codes, or the RF tags could be encoded with pertinent passenger information (for example, name, flight number, departure gate, departure time, destination). In the latter case, interfacing with airline systems would not be needed. Because RF tags have read/write capability, the tags could be updated

automatically at each security checkpoint to include security check results. At the departure gate, a final reading of each tag would confirm that the passenger/carry-on item had passed all security checkpoints.

- **Trace vapour detection technology is adequate**. Laboratory trials have demonstrated that trace vapour detection is about 70 percent effective and can detect explosives residue on the hands of a bomb maker or accomplice. While this percentage is not particularly impressive on its own, this technology does add to the overall detection process.

- **Integration could allow remote metal and explosives detection monitoring,** permitting modifications to detection thresholds to be made when increased security is required.

- **Integration of an X-ray system with other equipment types, while theoretically possible, would not often be practical**. Extraction of data from an X-ray unit would be an extremely complex project, which makes the Heimann 6040a a poor integration candidate.

- **Integration of X-ray systems would provide the opportunity to build a database of images**, which could be used for training and investigative studies. A database could also aid in the construction of automatic threat detection algorithms, which could be used to highlight suspicious objects. The following caveats, however, would apply:
  - **Image data from the Heimann 6040i may not be sufficient** to develop robust object detection algorithms. As a result, algorithms may yield unacceptably high levels of "nuisance" alarms by highlighting objects which, to the eye, are obviously not dangerous;
  - **Image data with three-dimensional information could be more usefully analyzed** than the two-dimensional data provided by Heimann-type equipment. Ideally, any object recognition program would provide immediate feedback to screeners. Integration of individual X-ray units with object recognition hardware and software might best be performed at the X-ray location.

Overall Recommendations

Integration would best be enabled in two stages. Stage one would involve looking at current pilot projects and investigating the most favourable integration candidates. Stage two would involve integrating innovative types of equipment, including types that are currently available and those still in development.

Stage One Integration

- Assess the effectiveness of Atlanta Airport's integration initiative. Initiatives at this location were unable to be adequately explored within the conduct of this project.

- Determine the usefulness of video capture technology already in use at Sea-Tac and Miami International Airport.

- Select a method of passenger and carry-on item identification (bar code, RF tag), and implement. Depending on the technology chosen, this may require integration with airline passenger systems.

Stage Two Integration

- Investigate passenger profiling systems, including the use of third party (RCMP, FBI) database information and biometrics.

- Integrate each CEIA 02PN10 metal detector with a central screening facility that uses CEIA-supplied software, for the purpose of gathering statistics. The statistics could then be used to select optimal threshold levels. This integration would also allow equipment sensitivities to be modified unobtrusively.

- Investigate the Heimann 6040i (X-ray) integration capabilities more fully and integrate each unit with a central screening facility for the primary purpose of data gathering and training. This integration would also enable images to be analyzed at the same time as the front-line screener performs the analysis. In parallel with integration steps outlined below, investigation can then begin in earnest into the use of expert system object recognition algorithms.

- Select a method of passenger and carry-on item identification (bar code, RF tag), and implement. Depending on the technology chosen, this may require integration with airline passenger systems.

- Integrate CEIA software with X-ray image data and with identification information. Present passenger identification information to front-line screeners.

- Select an explosives detection technology and integrate with existing equipment. Develop and implement a single user interface at each screening point showing explosives detection results, X-ray images and passenger information.

- Integrate checked baggage systems with passenger screening and information systems.

Project Follow-Up

The following are areas in which further research is or may be required to obtain a better understanding of the implications of technological advancement on airport/airline operations, and to determine the best alternatives for their use. In addition, initiatives that could assist in overall facility planning are indicated.

- **Development of screening line standards, layouts and configurations** – Miami International Airport is in the process of defining specific standards that will include all environmental and design issues. Further examination of this critical initiative and any others currently underway to optimize process flow would be beneficial.

- **Alternatives and their effectiveness** – Some countries have opted for other approaches to explosives detection, such as dual-scan X-rays, trace detection portals, or newer developments. The benefits and costs of these alternatives should be investigated.

- **Threat Risk Impact Assessment (TRIA)** – This process adds "Impact" to an analysis of threats/risks, and presents strategies to respond to risk levels. Many of the stakeholders contacted during the course of this project were not convinced that integration costs could be justified, given the range of other initiatives that could be pursued. One concern was that security would only be marginally improved, if at all, through the integration of security equipment. A TRIA would evaluate the impacts associated with particular risk levels, which would then drive initiatives aimed at mitigating the implications and risks.

- **Definition of the benefits of data integration** – Vendors will need to be motivated to incur the costs required to develop security equipment that is more amenable to data integration. Most vendors indicated that clear regulatory standards/support/mandates would be required to provide direction to the industry in order to achieve integration. These regulatory bodies would also need to clearly define the expected benefits of data integration in terms of detection rates, false alarms and passenger throughput rates.

Sommaire

Objectifs de l'étude :

- faire l'inventaire des matériels de sûreté, et de leurs configurations, actuellement en usage dans les aéroports nord-américains;
- élaborer un modèle de rationalisation et d'intégration des matériels;
- proposer une méthode pour réaliser cette rationalisation et accroître ainsi l'efficacité du processus global de filtrage de sûreté.

Des entrevues en profondeur avec des fabricants de matériels de sûreté, des organismes du monde de l'aviation, des agents de sûreté travaillant aux aéroports et diverses autres personnes-ressources ont permis de brosser un tableau du contexte actuel de la sûreté aéroportuaire et des technologies en usage. Parmi les matériels inventoriés, ceux qui semblaient les plus aptes à une intégration ont ensuite été examinés. Ces technologies dites «candidates» ont été réparties en deux groupes : les technologies existantes (*de base*) et les technologies émergentes, novatrices (*développées*). Au terme d'une évaluation des technologies de base, des scénarios d'intégration de ces technologies ont été étudiés. Le même exercice (évaluation et élaboration de scénarios) a été appliqué aux technologies développées.

Pour réaliser le troisième objectif, les chercheurs ont étudié le processus global de filtrage de sûreté, dans le but de déterminer la meilleure façon de mettre en œuvre des systèmes intégrés. Pour cela, ils ont évalué le potentiel d'intégration des matériels de sûreté aéroportuaire, et les incidences associées à diverses options d'intégration. Plusieurs options se sont avérées plausibles, mais le plus délicat était de cerner les plus viables et les plus avantageuses sur les plans technique, opérationnel et ergonomique. Les chercheurs ont appliqué un ensemble de critères clés aux options retenues et ils ont élaboré divers scénarios mettant en jeu des matériels existants d'une part, et des technologies et processus encore peu courants dans un environnement aéroportuaire, d'autre part.

Trois principaux critères ont servi à évaluer les technologies d'intégration des matériels : accélération de la cadence d'inspection, amélioration de la détection, diminution du nombre de résultats «faux positifs» lors du filtrage. Cet exercice a donné une idée des incidences «réelles» associées à l'application de technologies novatrices et intégrées à la sûreté aéroportuaire et des effets probables sur les passagers, sur les agents de sûreté et sur l'ensemble des opérations.

Au terme des entrevues, il est rapidement devenu clair que toute initiative visant à intégrer les matériels de sûreté aéroportuaire recevrait peu d'appui, surtout si elle devait rester isolée. Les personnes interrogées considèrent peu urgent d'intégrer les matériels, par rapport à d'autres actions jugées plus pressantes : formation des préposés au contrôle de sûreté, mise en place de nouvelles technologies permettant de meilleurs taux de détection, rationalisation du processus global de filtrage de sûreté et accélération de la cadence d'inspection, etc. Malgré les réserves exprimées, il reste que l'intégration des

matériels de sûreté aéroportuaire peut contribuer à améliorer le taux de détection, comme il est montré dans le rapport.

Principales observations et conclusions

Les observations et les conclusions découlant de l'analyse des technologies les plus propices à une intégration sont regroupées sous trois thèmes : les gens, les processus et la technologie.

Les gens (facteurs humains)

- **L'intégration n'entraînerait pas de réduction du personnel** affecté au contrôle des passagers parce que :
  - des taux d'alarmes élevés nécessitent une inspection matérielle et un contrôle «humain» fréquents des passagers et des bagages à main;
  - pour bien exploiter les appareils à rayons X, il faut contrôler les bagages un à un et les placer de façon à maximiser la taille de l'image et à éliminer le brouillage;
  - il faut un nombre suffisant d'employés pour que les passagers suspects soient rapidement appréhendés sans que soit ralentie la cadence d'inspection;
  - malgré les mises en garde claires aux points d'inspection primaires, les passagers négligent souvent de retirer les objets de métal de leurs poches, sacs à main, bagages, etc., ce qui oblige un agent de sécurité à intervenir.
- **Les préposés au contrôle de sûreté auraient à exploiter des dispositifs de détection d'explosifs intégrés** et à faire une inspection matérielle des objets et passagers suspects. On s'attend que les dispositifs de détection d'explosifs entraîneront un taux élevé de fausses alarmes, en raison du nombre d'objets inoffensifs susceptibles de déclencher des alarmes (certains médicaments pour le traitement d'affections cardiaques, par exemple).
- **Nécessité de donner une formation cohérente et approfondie aux agents de sécurité**. Parmi les intervenants rencontrés, nombreux sont ceux qui estiment qu'une grande part du risque se situe au niveau de la formation des préposés au contrôle. Au cours de visites effectuées dans les aéroports, des cas ont été observés où les préposés étaient embarrassés et confus quant à la façon de procéder pour traiter de forts débits de passagers. Une formation et une rémunération insuffisantes ont été cités au nombre des facteurs contribuant à cette situation, mais l'implantation des postes de contrôle, les pénuries de personnel et la mauvaise utilisation des matériels sont aussi à blâmer.

Les processus (contrôle des passagers et des bagages)

- **L'intégration des matériels de sûreté et des systèmes d'identification des passagers** permettrait, avec l'adjonction d'un système expert, de déterminer quels passagers doivent être soumis à un contrôle plus poussé dans un poste de contrôle central. Par exemple, toutes les images radioscopiques des bagages à main et des bagages enregistrés d'un passager seraient examinées à un poste central et, le cas échéant, le passager serait appréhendé à la porte d'embarquement (contrôle des passagers assisté par ordinateur).

- **L'intégration des matériels donnerait l'occasion de réunir des données statistiques sur la fréquence des alarmes et sur les données recueillies par les dispositifs de détection d'explosifs**. Conjuguées aux dossiers papier tenus par les agents de sécurité et documentant les résultats des contrôles secondaires, ces données pourraient servir à optimiser la performance des détecteurs d'explosifs, en aidant à déterminer un niveau optimal de détection. Le même principe pourrait s'appliquer aux détecteurs de métaux.

- **L'inspection humaine des images radioscopiques des bagages enregistrés, combinée à l'information sur les passagers** (obtenue par une étiquette code-barres/radio apposée sur le bagage) pourrait mener à sélectionner davantage de bagages pour un contrôle manuel. En ayant accès, depuis le point de contrôle de sécurité des passagers et la porte d'embarquement, au système d'inspection des bagages enregistrés, les préposés au contrôle pourraient être plus facilement alertés, ce qui permettrait d'appréhender plus rapidement les passagers suspects.

- **La mise à contribution du personnel préposé aux files d'attente permettrait d'augmenter sensiblement la cadence d'inspection**. On a observé une diminution sensible du nombre de passagers se présentant à la mauvaise zone de contrôle ou au mauvais comptoir d'enregistrement, lorsque des employés étaient présents pour venir en aide aux passagers faisant la queue. L'aide apportée était aussi simple que confirmer au passager qu'il était dans la bonne file et qu'il avait les bons documents en mains.

- **Les personnes qui traversent les points de contrôle ne sont pas toutes des passagers**. Dans la plupart des aéroports américains, le public est admis au delà des points de contrôle de sûreté. Ces personnes, qui viennent à la rencontre de passagers arrivants, ne sont pas assujetties à la vérification des cartes d'embarquement, comme les passagers. On leur demande seulement de passer au détecteur de métal et de soumettre leurs bagages à main à l'appareil à rayons X et/ou à un contrôle manuel.

La technologie (intégration)

- **L'intégration des systèmes de détection et d'un système d'identification des passagers** permettrait d'établir le profil complet de chaque passager. Ces profils pourraient être consignés et archivés, puis récupérés ultérieurement, pour diverses fins. Le système d'identification des passagers pourrait contenir des données comme le numéro du vol, la compagnie aérienne et la destination.

- **Pour être utile, l'intégration devrait comprendre des fonctions d'identification des passagers et des objets**. Deux options ont été examinées :

  - Apposer des étiquettes à code-barres sur les cartes d'embarquement et sur tous les objets, au moment de l'enregistrement. Aux points de contrôle de sécurité, la lecture des codes-barres et l'interrogation des systèmes des compagnies aériennes permettrait d'établir les données sur le passager (nom, numéro de vol, porte d'embarquement, heure de départ, destination).

  - Apposer des étiquettes-radio sur les cartes d'embarquement et sur tous les objets, au moment de l'enregistrement. Les étiquettes-radio pourraient être utilisées de la même façon que les étiquettes code-barres, ou encore être codées en fonction de certaines données concernant le passager (nom, numéro de vol, porte d'embarquement, heure de départ, destination). Dans ce dernier cas, il ne serait pas nécessaire de prévoir une interface avec les systèmes des compagnies aériennes. Comme les étiquettes-radio sont ré-inscriptibles, les résultats d'inspection à chaque point de contrôle pourraient être automatiquement incorporés aux étiquettes. À la porte d'embarquement, une dernière lecture de chaque étiquette confirmerait que le passager/bagage à main a traversé tous les points de contrôle de sécurité.

- **La technologie de détection des vapeurs à l'état de trace est au point**. Des essais en laboratoire ont démontré que la détection des vapeurs à l'état de trace (présence de résidus d'explosif sur les mains d'un fabricant de bombe ou d'un complice) est efficace à environ 70 p. cent. Ce pourcentage n'est peut-être pas très impressionnant en soi, mais cette technologie constitue un complément précieux au processus global de détection.

- **L'intégration des matériels ouvre la voie à la surveillance à distance des détecteurs de métaux et d'explosifs,** ce qui est de nature à faciliter la modification des seuils de détection lorsqu'il est nécessaire de renforcer la sécurité.

- **L'intégration d'un détecteur à rayons X aux autres types de matériels, bien que possible en théorie, serait peu envisageable en pratique**. L'extraction des données d'un appareil à rayons X serait une entreprise extrêmement complexe, ce qui rend le matériel Heimann 6040a peu propice à une intégration.

- **L'intégration d'appareils à rayons X donnerait l'occasion d'édifier une base de données d'images,** lesquelles pourraient servir à des fins de formation et d'enquêtes. Une base de données pourrait également aider au développement d'algorithmes de détection automatique des menaces, qui pourraient être utilisés pour mettre en évidence des objets suspects. Voici toutefois quelques mises en garde :
  - **Les images du Heimann 6040i ne seraient peut-être pas suffisantes** pour développer des algorithmes robustes de détection d'objets. D'où le risque que ces algorithmes mènent à un nombre élevé d'alarmes intempestives, en détectant des objets qui, à l'examen visuel, se révèlent inoffensifs;
  - **Les images découlant de données tridimensionnelles pourraient être plus utiles à analyser** que les données bidimensionnelles fournies par le matériel de type Heimann. Idéalement, tout programme de reconnaissance d'objets donnerait une rétroaction immédiate aux préposés. Il serait plus avantageux d'intégrer les appareils à rayons X et les matériels et logiciels de reconnaissance d'objets là où se fait le contrôle radioscopique.

Recommandations globales

Il serait préférable de procéder à l'intégration en deux étapes. La première étape comporterait l'examen des projets pilotes en cours et l'étude des technologies les plus prometteuses en vue d'une intégration. La deuxième étape comporterait l'intégration de types novateurs de matériels, y compris des matériels qui existent déjà et d'autres qui sont en cours de développement.

Première étape d'intégration

- Évaluer les résultats du projet d'intégration réalisé à l'aéroport d'Atlanta. Les initiatives mises en œuvre à cet endroit n'ont pu être examinées de façon satisfaisante dans le cadre du présent projet.
- Déterminer l'utilité de la technologie des caméras vidéo en usage aux aéroports internationaux de Sea-Tac et de Miami.
- Choisir une méthode d'identification des passagers et des bagages à main (codes-barres, étiquettes-radio) et en faire la mise en oeuvre. Selon la technologie choisie, intégrer celle-ci, au besoin, aux systèmes d'information sur les passagers des compagnies aériennes.

Deuxième étape d'intégration

- Étudier les systèmes d'établissement des profils passagers, y compris le recours à l'information et aux données biométriques contenues dans les bases de données de tierces parties (GRC, FBI).

- Intégrer chaque détecteur de métal CEIA 02PN10 à un poste d'inspection central utilisant un logiciel CEIA, aux fins de la collecte de statistiques. Ces statistiques serviraient ensuite à choisir des seuils optimaux de détection. Cette intégration permettrait également de régler à distance la sensibilité des matériels.

- Étudier plus attentivement les capacités d'intégration du matériel Heimann 6040i (rayons X) et intégrer chaque appareil à un poste d'inspection central à des fins de collecte de données et de formation. Grâce à une telle intégration, le préposé au poste de contrôle central pourrait analyser les images en même temps que le préposé travaillant en première ligne. Parallèlement aux étapes d'intégration décrites ci-après, on peut se lancer sérieusement dans la recherche sur le recours à des algorithmes de reconnaissance d'objets de système expert.

- Choisir une méthode d'identification des passagers et des bagages à main (codes-barres, étiquettes-radio) et en faire la mise en oeuvre. Selon la technologie choisie, intégrer celle-ci, au besoin, aux systèmes d'information sur les passagers des compagnies aériennes.

- Intégrer le logiciel CEIA aux images radioscopiques et aux données d'identification. Présenter les données d'identification des passagers aux préposés au contrôle de première ligne.

- Choisir un matériel de détection d'explosifs et l'intégrer au matériel existant. Développer et mettre en œuvre une interface mono-utilisateur pour chaque point de contrôle montrant les résultats de la détection d'explosifs, les images radioscopiques et les données sur les passagers.

- Intégrer les systèmes afférents aux bagages enregistrés aux systèmes de filtrage de sûreté des passagers et aux systèmes d'information sur les passagers.

Suivi du projet

Sont énumérés ci-après les secteurs dans lesquels d'autres travaux de recherche devraient ou pourraient être entrepris afin de mieux comprendre les incidences des percées technologiques sur les activités des aéroports et des compagnies aériennes, et de déterminer les meilleures options pour la mise en service de ces nouvelles technologies. Des mesures pouvant faciliter la planification globale des installations sont également proposées.

- **Élaboration de normes, de schémas d'implantation et de configurations pour la planification du processus d'inspection** – L'aéroport international de Miami est à définir des normes précises qui engloberont toutes les questions touchant l'environnement aéroportuaire et la conception des installations. Il serait bon de suivre attentivement le déroulement ces travaux cruciaux et de tout autre projet semblable en cours visant l'optimisation du processus d'inspection.

- **Autres technologies possibles** – Certains pays ont opté pour d'autres méthodes de détection des matières explosives, comme la radioscopie à double balayage, les portiques de détection de vapeurs à l'état de trace, ou d'autres techniques de pointe. Il y aurait lieu d'étudier les coûts et les avantages associés à ces autres solutions.

- **Évaluation des répercussions des menaces et des risques (ERMR)** – L'analyse doit viser non seulement les menaces/risques, mais aussi les «répercussions» et proposer des stratégies selon les niveaux de risque. Peu des intervenants consultés au cours du projet étaient convaincus que les coûts d'une intégration puissent être justifiés, compte tenu de toutes les autres initiatives souhaitables. Plusieurs craignent que l'intégration des matériels de sécurité améliorent très peu, ou pas du tout, la sécurité. Une ERMR permettrait d'évaluer les répercussions associées à divers niveaux de risque, après quoi des mesures pourraient être prises pour atténuer les incidences et les risques.

- **Définition des avantages de la fusion des données** – Il faudra convaincre les fournisseurs d'investir dans le développement de matériel de sécurité qui se prête mieux à la fusion des données. Selon la plupart des fournisseurs rencontrés, l'industrie devra être guidée par des normes, un soutien et des mandats réglementaires clairs, pour que puisse être réalisée la fusion des données. Il importe également que ces organismes de réglementation définissent clairement les avantages escomptés de la fusion des données, sous l'angle des taux de détection, des fausses alarmes et des cadences d'inspection.

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Glossary

ATB	Automated Ticket and Boarding Pass
BCD	Boarding Control Devices
BRS	Baggage Reconciliation Systems
BSM	Baggage Source Message
CAPS	Computer-Assisted Passenger Screening
DOT	Department of Transportation
EDS	Explosives Detection Systems
FAA	Federal Aviation Administration
GAO	General Accounting Office
GTAA	Greater Toronto Airport Authority
HFE	Human Factors Engineering
IATA	International Air Transport Association
IT	Information Technology
LED	Light Emitting Diode
MIA	Miami International Airport
PPBM	Positive Passenger Baggage Matching
RCMP	Royal Canadian Mounted Police
RF	Radio Frequency
RFID	Radio Frequency Identification
SID	Simultaneous Identification
SO	Security Officer
SPEARS	Screener Proficiency Evaluation and Reporting System
TDC	Transportation Development Centre
TEDS	Trace Explosives Detection Systems
TIP	Threat Image Projection
TRA	Threat Risk Assessment

1 INTRODUCTION

This report considers the ability and feasibility of integrating airport security equipment within the context of the current security environment, including infrastructure, staffing, regulatory and procedural issues. A number of scenarios are presented for various configurations of integrated equipment to improve the efficiency and effectiveness of airport security screening. The report also examines the way in which integration affects overall security, by analyzing various levels of threats and risks, and determining their impact. In addition, the importance of integration relative to other initiatives is presented through extensive interviews with vendors, security services and airport agencies.

1.1 Background

The recent proliferation of aviation technology, including the development of new forms of security and the expansion of ticketless travel, has raised questions regarding the future appearance of passenger processing.

Transport Canada and the Federal Aviation Administration (FAA) have signed a U.S./Canada bilateral agreement on cooperative research and development concerning counter-terrorism. This is the third recent initiative, following a first project on electronic ticketing and its impact on airport security, and a second relating to the fusion of security information from existing airport security equipment. The current project focusses on integrating existing airport security screening equipment, with emphasis on the following:

- Improving the overall screening process by making the screeners and the equipment infrastructure as effective as possible in determining potential threat situations.
- Enhancing the system efficiency, ensuring passengers are processed more quickly.
- Improving the overall system aesthetics to create a desirable working environment for screening personnel and to increase passengers' confidence in the security screening system.

1.2 Objectives of the Study

The hierarchy of objectives of the Transportation Development Centre (TDC) in undertaking the proposed study is as follows:

- **Modal objective**: To develop expertise and techniques with respect to equipment in support of security requirements to increase the safety of travellers using contemporary air transportation.
- **Modal sub-objective**: To develop and evaluate innovative systems for detecting goods that present a threat to the safety of air travellers.

- **Project objective**: To identify the various types of security screening equipment that are present in an airport facility, and to document their use and operation with respect to their specific functionality. Another objective is to develop a concept for equipment consolidation/integration, and propose a methodology to achieve this consolidation in order to improve the overall efficiency of the security screening process. This integrated equipment concept relates primarily to the passenger screening and carry-on baggage area with the intent to enhance the overall passenger security screening process for the detection of concealed weapons and explosives.

While these research objectives are ultimately focussed on the issue of the application of technology to security, it is important that this research be directed by a clear understanding of current issues and trends in airport and airline operations as well as passenger facilitation, and the implications of these trends for security requirements.

2 CONTEXT OF STUDY

A principal goal of airport security operations is to provide not only for the security and safety of travellers, but also that of other persons both inside and outside the airport itself. Failure of security operations to identify potential threats may result in a disaster such as the PanAm 107 flight, which took the lives of passengers as well as those on the ground.

Security operations within an airport environment comprise several individual yet mutually supportive components. These components include passenger profiling, passenger-to-ticket matching, behavioural observations, technological inspection processes, baggage matching, and hands-on or visual inspection by screeners. All components need to function at a high level of efficiency for the overall protective envelope to meet its mandate successfully on a continuing basis.

In any environment where successful operations depend on a certain level of throughput, functions that give the impression of slowing or impeding operations will be regarded with a jaundiced eye. Such is normally the case in environments where passengers, baggage and equipment are processed, especially if travellers do not recognize or understand the reason for delay. In this type of environment security operations must serve, but not be subservient to, the needs of the airport authority and the air carriers.

Security, as well as airport operations, may be affected by the manifestation of both natural and manufactured incidents. These incidents may surface without notice and continue for an extended period of time. The ability to adapt, for both human and technological elements, is crucial. This flexibility is realized, however, as a result of a sound strategic planning process and is not simply a function of technology.

Airport security operations will continue to focus on maximizing processing efficiency while maintaining an appropriate level of security screening for both passengers and baggage, given an identified threat risk environment. Many agencies contribute to determining the threat and risk level in place at any specific moment. It is our understanding that the threat and risk process used by these agencies is appropriate and understood by the airport authorities.

2.1 Current Security Environment

At a time when matters of airport security and threats to its integrity are mentioned on every newscast, there is increasing public pressure to ensure that systems are optimized for maximum passenger and baggage safety. In his address to the International Aviation Club and Aero Joint Club Meeting in Washington, D.C. on February 2, 2000, U.S. Secretary of Transport Rodney E. Slater stated:

> "I respectfully submit that any discussion of the future of transportation or aviation in particular must begin with a focus on safety. The tragedy of Flight 261 is a sobering reminder of that fact. Despite having already achieved the safest skies in the world, we must as 'visionary and vigilant' transportation professionals, continue

to raise the bar on safety. Safety remains President Clinton's top transportation priority and the 'North Star' guiding our work at the U.S. Department of Transportation."

2.2 General Observations on Airport Security

2.2.1 People (Human Factors)

Within the airport security process, the operators of security equipment are considered to be the weakest link. Pressing issues include screener training and random testing of threat detection accuracy. In our airport observations, we noted large variations in staff-to-volume ratios, as well as different levels of effectiveness in screening personnel. A challenge faced by the majority of airports in North America is the ability to provide efficient, adequately trained staff to operate security equipment. Lower wages and poor commitment to ongoing training programs were often cited as root causes of varying performance. Progress in each of these areas is fundamental to ensuring that the security process is as effective as possible.

2.2.2 Process

While general security operations were found to be fairly consistent at the airports observed, management of the screening process varied considerably. In one airport, single metal detection portals were used when passenger volumes were at a particular level, while twin portals were used at another airport for identical volume. The number of X-ray machines also varied, with passenger volume remaining constant. There were different approaches to queue management, particularly in the selective use of security staff giving verbal instructions to passengers waiting for primary inspection. As with the changing state of the equipment itself, processes also varied by airport.

2.2.3 Technology (Equipment)

If there was one recurring comment from security equipment manufacturers, it was that "nothing is constant". The pace of change is rapid, as are the demands of the industry for more innovative ways to accomplish three principal goals: improve process flow, increase detection, and reduce false positives. Integration does not appear to be widely held as a priority, evidenced in the fact that few pieces of equipment are able to integrate with one another. This is the case between manufacturers, and even within one manufacturer's product line. Image formats are also proprietary, resulting in integration constraints. Based on our interviews, it seems as though the relevant government agencies are the largest proponents of equipment integration.

We observed a greater automation of equipment to support the decision-making process of an equipment operator, as well as an increase in instrument sensitivity. This increase is principally to keep up with new threat levels at airports around the world. This and other changes have significant process implications, particularly as more steps are added to the security process. Innovations do not come without a cost, both financial and in the physical space that additional equipment may take within the airport environment. An interesting innovation is the advent of screener interface modules that not only display given information on baggage content, but also effectively "coach" screeners through threat resolution decisions. Computer algorithms recognize threat characteristics and instruct screeners on which tools and functions must be used to determine the validity of a threat. This coaching utilizes the system's detection capabilities and guide screeners through established threat resolution protocols.

2.2.4 Industry

There is a trend toward the consolidation of security equipment manufacturers, most recently the merge between Perkin-Elmer and Vivid Technologies. Growth in the market is currently driven by the need to replace older equipment (e.g., new legislation requiring second generation X-ray explosives detection in the United States). The long-term market is strengthening as world airports and aviation administrations move toward the goal of 100 percent checked baggage screening. This will be aided by increased air travel forcing airports to redesign or build new terminals.

2.3 Government Mandates and Initiatives

2.3.1 Transport Canada

In the area of airport security, Transport Canada's mandate is as follows:

"The Government of Canada recognizes the need for a realistic, achievable vision for transportation and new partnerships to move the Canadian transportation system into the 21st century. Efficient, reliable, safe, competitively-priced and environmentally-sound transportation systems to move people and goods are essential to maintain Canada's competitive edge" (http://www.tc.gc.ca/airports/nap/english/p1.htm). To accomplish this, Transport Canada commissions a number of projects and studies through its various agencies, including the Transportation Development Centre.

2.3.2 Federal Aviation Agency (FAA)

The FAA's mandate is to prevent security incidents in the aviation system through a number of initiatives. In the area of explosive device and weapons detection, it seeks to increase the ability to detect improvised explosive devices (through use of stimulants) and weapons in checked and carry-on baggage. This is to be accomplished with no significant increase in operational impact. The FAA also ensures compliance with security requirements, as measured by compliance audits. In addition to this, the FAA evaluates risk and vulnerability at airports and airway facilities.

2.4 People – Human Factors

The effectiveness of any technology development or integration will be defined in terms of integration within the human-machine system, performance, usability, availability, reliability and maintainability, as well as the effect on communication, performance, processing and efficiency.

Figure 1 illustrates the role of ergonomics and human factors in the planning, evaluation, design, installation and post-development evaluation stages of system development, which may include the examination of potential candidates for technology integration.

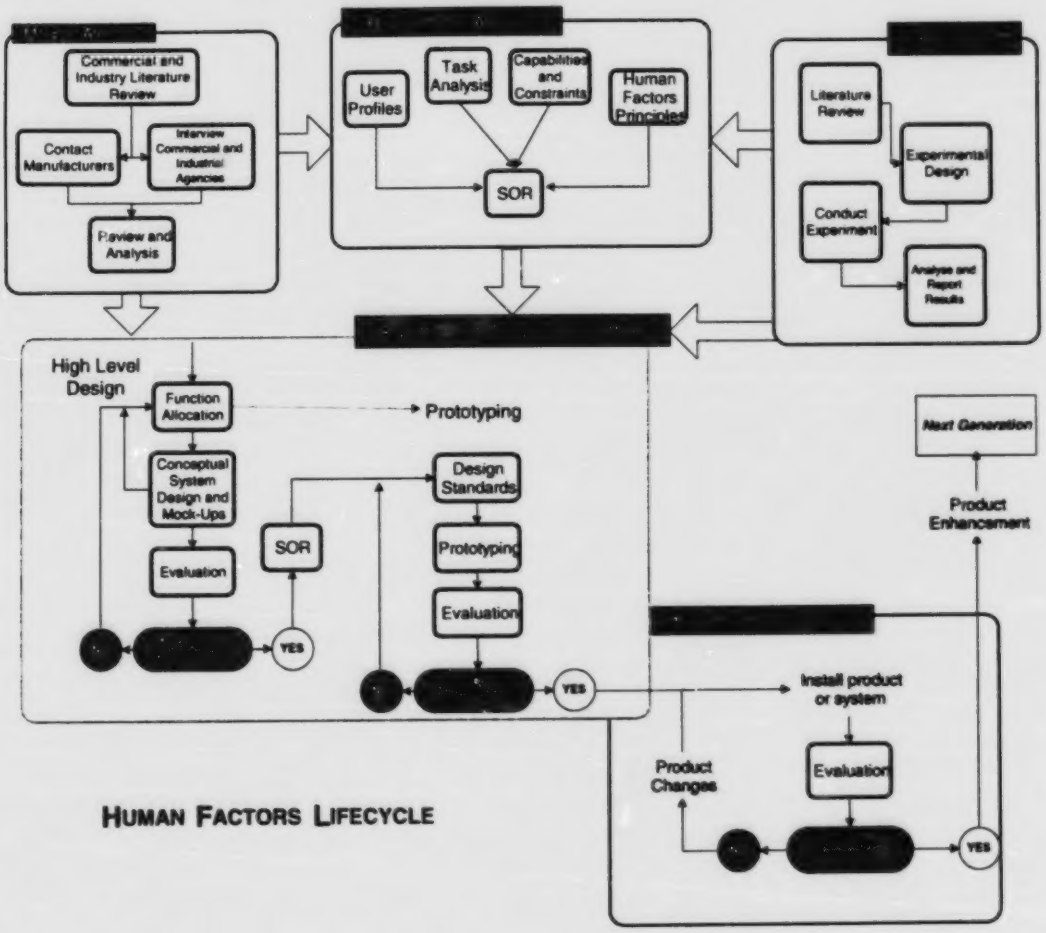


Figure 1: The Human Factors Lifecycle (adapted from Mayhew, 1999)

The value of including ergonomics and human factors from the beginning of the design cycle helps ensure each part of the system is integrated with the other parts, and the human and system integration is maximized. This process, as depicted in Figure 1, optimizes utility, safety, usability and productivity. During the vendor interviews, company representatives reported using human factors usability in the design and evaluation of their technological systems. Integration of various technologies, however, will require an additional level of human factors consideration to ensure the development of an optimal function allocation and interface between the security screening system and its users.

Prior to the integration of any technology, it is recommended that additional focus be placed on the Human Factors Lifecycle (Mayhew, 1999), including development of complete user profiles and requirements, integrated information displays, hardware requirements, mock-ups, usability testing with end-users, and feedback to a complete system design. This process will ensure that the physical, cognitive, training and task requirements of all end-users have been considered and met in the final system design.

The FAA and airlines are deploying elements of the Screener Proficiency Evaluation and Reporting System (SPEARS), a major FAA effort to improve training and monitor screener effectiveness. SPEARS has computer-based training modules, which are effective and efficient methods for training screeners. Training systems for screeners using X-ray machines at security checkpoints have been installed at 17 major airports. They will soon be available for explosives detection systems and trace explosives detection devices.

The FAA continues to take human factors into account by providing appropriate training and developing utilization standards, clear guidance and operational procedures in partnership with the airlines to ensure the effective use of security equipment by trained and properly motivated air carrier personnel. The FAA is also taking steps to improve initial and recurrent training curricula for both checkpoint supervisors and screeners.

Threat Image Projection (TIP), is a system whereby artificial images of improvised explosives devices and other threat objects are presented to the screener during the performance of normal duties as if objects were actually in the baggage. The screener's decisions are tabulated and recorded to furnish real-time feedback for effectiveness monitoring and as a training tool. Approximately 300 TIP systems are being deployed in airports throughout the world.

The need for rapid, effective security screening technologies and processes to enhance the safety of air travellers is recognized across the field of aviation and its peripheral industries. This need is the particular focus of several organizations and committees around the globe. For example, the White House Commission on Aviation Safety and Security, chaired by U.S. Vice President Gore, has repeatedly urged increased emphasis on equipment that will detect illegal and harmful devices using dual energy/dual view X-ray, magnetic resonance X-ray and trace explosive residue detection-based technologies. Other screening processes, such as automated passenger profiling, are also viewed as critical to the goal of increased safety and security.

At present, more than 25 companies throughout the world research, develop and market security equipment and instruments that screen passengers and their baggage using a variety of fundamental scientific processes and equipment configurations. These include systems that utilize ion vapour characterization, neutron stream analysis, nuclear magnetic resonance, thermal neutron activation and vapour trace analysis in several configurations.

Airport security and passenger screening processes need to function in a seamless fashion and effectively support the business operation of the airport. A key ingredient in successful application of security screening technologies is the training and continuing preparedness of airport security staff. As with any technology system, its effectiveness is highly dependent upon those who operate it. This is especially the case with emerging technologies, which in some cases will require higher screener skill levels.

2.5 Aviation Security Threats and Risks

2.5.1 Continuing Threats and Risks

Governments, air carriers, airport management and the travelling public continue to be concerned about the risk of terrorist or criminal activity at airports and, specifically, aboard aircraft in flight. Although the level of risk fluctuates depending on global tensions, passengers are increasingly concerned that regional conflicts in other parts of the world are more than ever being brought into their environment. In essence, the impact of regional conflicts and ethnic disputes is being felt further afield than ever before. In addition to the fear of explosives being smuggled onto an aircraft, airport operators and air carriers continue to be faced with everyday issues such as passengers attempting to board with smaller offensive weapons.

2.5.2 Application of Threat Risk Assessment

Successful development of an integrated inspection system depends on the establishment of criteria identified through the Threat Risk Assessment process (TRA). This process serves as a foundation to the integration process and verifies that realistic threats, both existing and future, are considered in the development cycle. For example, some potential future threats may not be detectable by one or more of the technologies proposed for use; however, all realistic threats should be detectable by at least one component of the integrated process.

The TRA process should also be applied on a regular basis to ensure developed processes continue to meet the challenges of developing threats such as new materials or explosive compounds that may become available to terrorists or disturbed individuals.

3 PROCESS EVALUATION

Canadian airports have five primary checkpoints, where passengers, their documents or their luggage are subjected to some form of scrutiny. These five checkpoints and the security technologies employed at each, are as follows:

1. **Check-in counter screening**: Passengers' checked baggage is weighed and tagged. Passengers may be asked to confirm that they packed their own bags. Boarding cards are issued. For international flights, passenger identification is inspected. Airline personnel interface with airline computers and databases during screening.

2. **Passenger screening**: Boarding cards are manually inspected, and the passenger is screened for metal objects. Screeners monitor the metal detection portal and employ hand-held metal detectors as needed.

3. **Carry-on baggage screening**: Items are X-rayed and images are manually analyzed. Suspect items are manually searched. In most Canadian airports, screeners use the Heimann 6040a X-ray machine.

4. **Checked baggage screening**: Some checked baggage (for international flights) is X-rayed.

5. **Boarding gate**: Boarding cards are manually inspected. Reconciliation of passengers and checked baggage may be done (international flights only). Airline personnel interface with airline computers and databases.

With reference to the integration objectives, the passenger and carry-on baggage screening checkpoints are the obvious choices for integration. The technologies employed for passenger and carry-on screening are mature, generally uniform across Canadian airports, and can be expanded to include new technologies (such as explosives detection and passenger profiling). These technologies can also be integrated without access to airline computers and databases. In addition, it is known that the performance of screeners and existing technologies is currently not optimal. Security equipment integration and its implications cannot be fully considered without an understanding of the human factor and process implications.

3.1 Passenger Screening

At Canadian airports, passengers are subject to a typical three-step process before being allowed to progress beyond the initial security gate:

- passenger presents a valid boarding ticket card or ticket, whether paper or electronic (i.e., only passengers are allowed to progress past this point);
- passenger passes through a walkthrough metal detector;
- passenger may be scanned using a hand-held metal detector.

The security equipment for step 2 is usually the CEIA 02PN10, whereas the security equipment for step 3 is usually the Garrett Superscanner (distributed by Heimann).

In Figures 2 through 5 on the following pages, various process flows have been mapped from reservation to boarding. Specific process variations are indicated in each diagram.

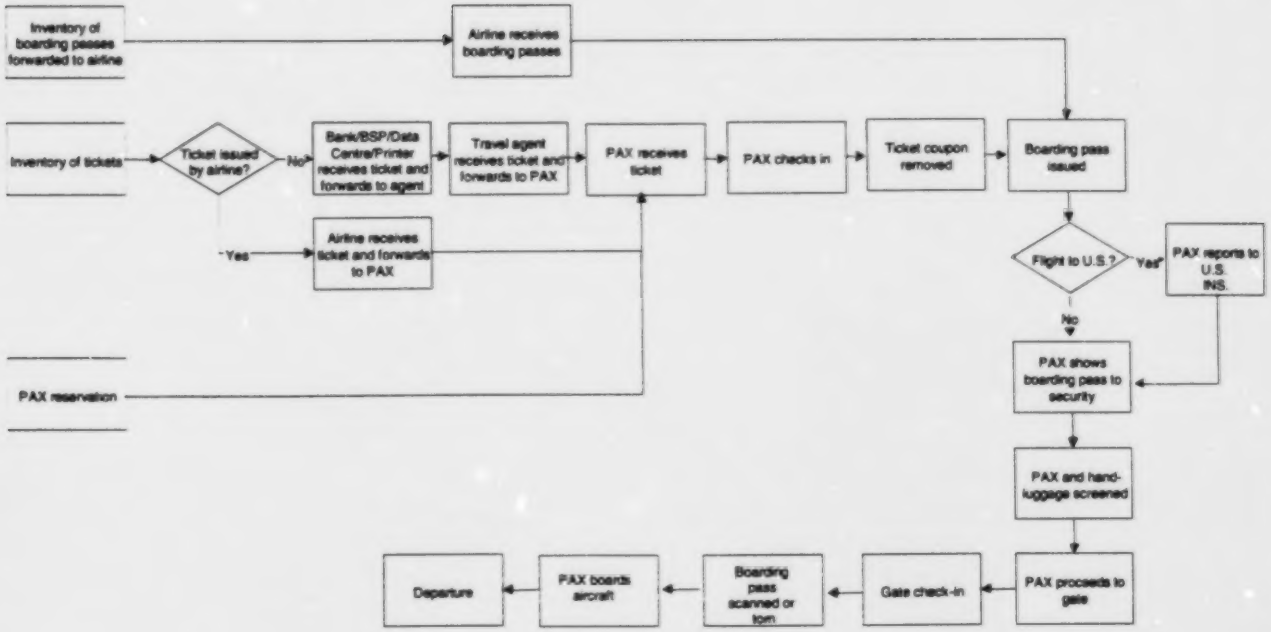


Figure 2: Process Flows – Paper-based processing (passenger with luggage)

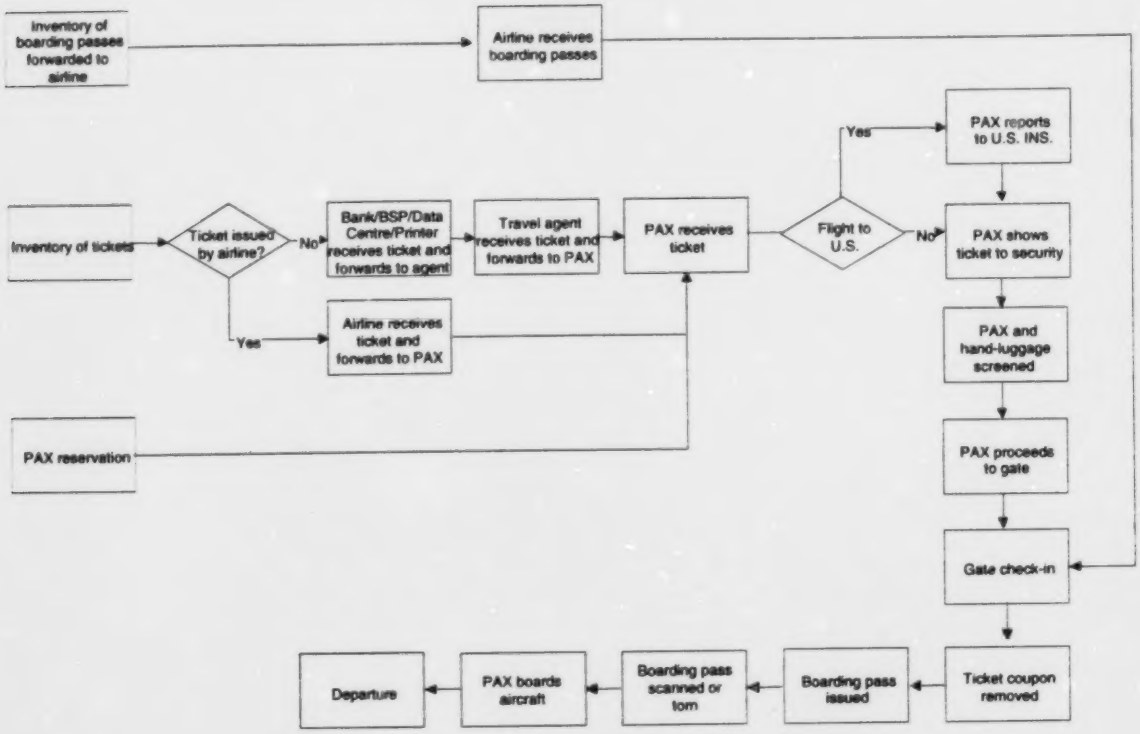


Figure 3: Process Flows – Paper-based processing (passenger without luggage)

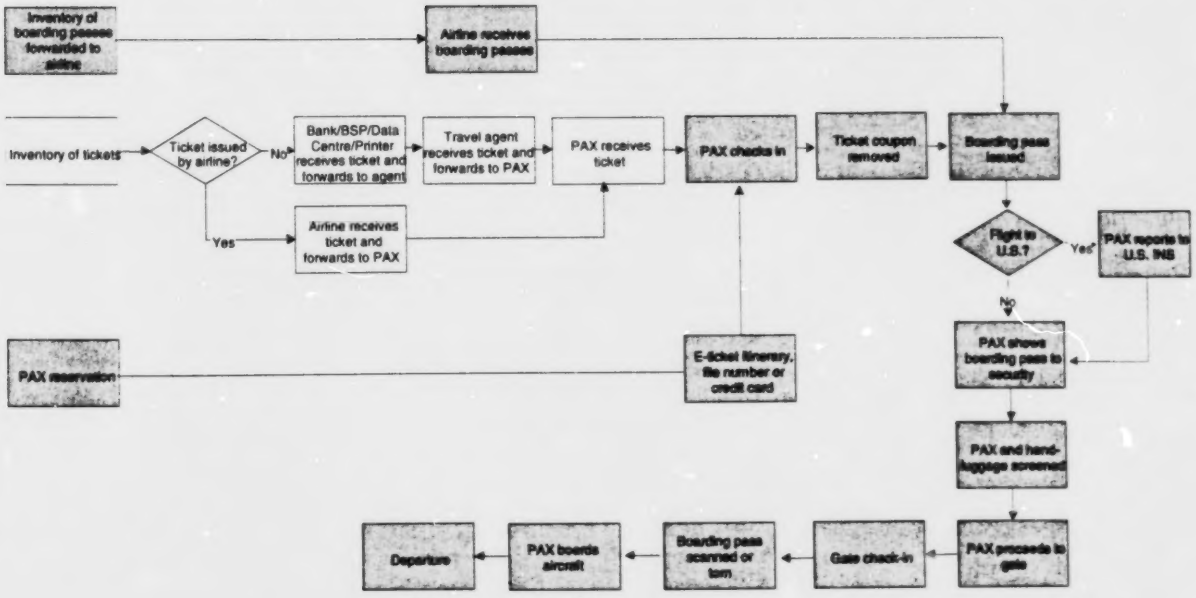


Figure 4: Process Flows – Electronic ticketing with paper boarding pass (passenger with luggage)

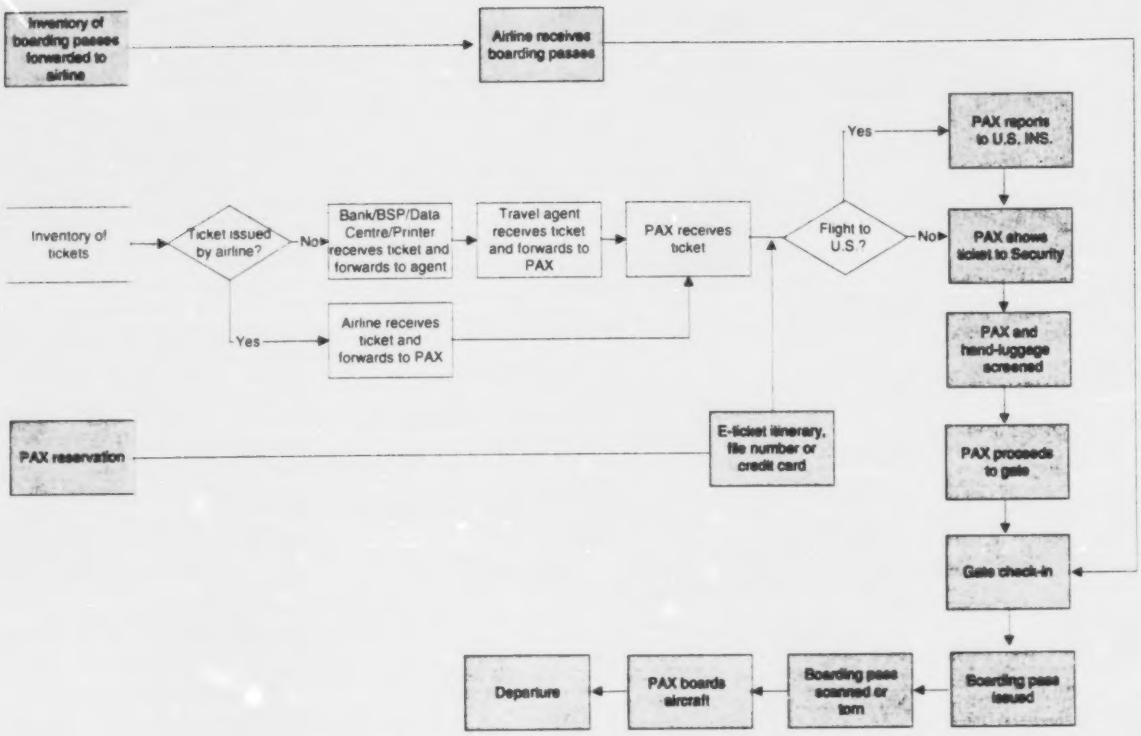


Figure 5: Process Flows – Electronic ticketing with paper boarding pass (passenger without luggage)

To understand clearly how airports operate within Canada and the United States, it is important to know the roles and responsibilities of the key stakeholders, as depicted in Table 1.

Table 1: Responsibility of air carriers, airport operators and government for passenger screening

Entity	Responsibility	Action
Air Carriers	Provide secure travel	Maintain security program Screen passenger/carry-on baggage Secure baggage/cargo Protect/secure aircraft
Airports	Provide secure operating environment	Maintain security program Protect operations area Provide law enforcement support
FAA/Transport Carrier	Provide administrative and procedural guidance	Identify/analyze threats Establish requirements/procedures Coordinate crisis situations Provide technical assistance Enforce regulations
Passenger	Cooperate	Fund carrier/airport security via travel purchase

Source: Airline Passenger Security Screening, National Research Council, 1996

3.1.1 Operational Issues for Air Carriers

For air carriers, quick and inexpensive screening of passengers and carry-on baggage is a major concern. Based on estimates of traveller loads throughout the day at a particular airport, air carriers must purchase and deploy an optimum number of screening devices and screening personnel. Air carriers often hire independent firms to operate security checkpoints. These firms provide both equipment and personnel, but the ultimate responsibility for securing screening remains with the air carriers.

3.1.2 Operational Issues for Airport Facilities

As shown in Table 1, airport facilities are also charged with developing and implementing security procedures. The goal of the airport operator is to provide a secure environment in which carriers can operate. This includes offering law enforcement support to air carriers when threat objects are identified through passenger screening procedures.

Airport operators are most concerned with the space requirements of safety and security programs instituted at airports. The space requirement issue encompasses the physical area required to establish a security checkpoint and the area required for the queuing of passengers and accommodation of baggage handling equipment. Facility space requirements involve more than simple square footage. Both the three-dimensional volume and the weight of each piece of equipment must be included in the equation for determining the space needed and other location requirements for establishing a screening checkpoint.

Newer designs for airport terminals have taken into account the requirements of passenger screening operations, based on the best estimates of the demands for equipment and operational space, and for the queuing space required for projected passenger loads. Equipment and operational space is determined by the number of checkpoints and the size of the equipment the air carrier wishes to install. Queuing space is directly linked to projected passenger traffic, which depends on the size of aircraft and the number of flights anticipated by the air carrier.

Older airport facilities designed and built before hub operations or passenger screening are often strained to meet the current space requirements, especially when changes in operational procedures require additional equipment for each passenger screening point.

3.2 Baggage Screening

In North America, carry-on baggage screening is performed by requiring all carry-on baggage to pass an X-ray inspection and/or a direct visual inspection. In addition, a variety of alternative Explosives Detection Systems (EDS) are undergoing development and trials. Some of these technologies are in place at certain U.S. airports including Seattle and San Francisco.

Current X-ray inspection systems are of the low-dose or low-radiation type. Two types of units are in operation in North America: stored-image units and continuous-beam units. The older continuous-beam units use an X-ray beam that is activated throughout the time the bag is being inspected, typically several seconds. For these units, the total X-ray dosage depends on the time the bag is inspected. The newer stored-image units, however, provide greater flexibility in inspection times as well as lower dosages of radiation. Because of these advances, stored-image units have replaced most of the continuous-beam units.

The stored-image units use a short pulse (on the order of 1 ms) of X-ray radiation. The resulting image is digitized and stored in digital memory. The stored images can then be inspected even though the bag is no longer being radiated.

1. **Basic X-Ray Systems:** Basic X-ray inspection systems rely on the principle that the raw X-ray image allows the screener to distinguish between different types of materials inside the baggage. The X-ray image provides an estimate of the

X-ray attenuation coefficient of the different regions within the bag. Since different materials have different X-ray attenuation coefficients, the raw image portrayed as a gray-scale image (darker gray corresponding to greater attenuation) provides a screener with a rough ability to determine what is in the bag.

2. **Advanced X-Ray Systems:** Modern stored-image units provide material discrimination systems of greater sophistication than such raw gray-scale images. These systems discriminate between different classes of material by making measurements in two or more energy regions. X-ray photons with relatively low energy (below about 80 keV) are strongly absorbed by the heavier elements (photoelectric absorption), but not by the lighter elements. Conversely, at higher energy levels, Compton scattering is the predominate mechanism for absorption. With Compton scattering, the rate at which absorption increases with atomic number is approximately linear, which is much slower than for the photoelectric absorption (where the rate of increase is approximately the fifth power of the atomic number). The conclusion from this is that measurement of absorption ratios at two or more energy levels can theoretically determine the effective atomic number of a given region, once the system is calibrated for known materials. Thus modern X-ray units exploit this fact, allowing automatic colour coding of the images according to their broad elemental composition.

   While X-ray systems of various types are still the primary method of screening baggage for weapons and explosives, a variety of alternative EDS systems have been developed, including measuring nitrogen concentration using neutron radiography, the use of non-ionizing radiation to examine baggage items, and the use of vapour detection devices. At some airports, these alternative methods are used in conjunction with X-ray systems, or as a secondary screening device if a suspicious object or threat is detected. One of the most promising areas for data fusion is the potential to improve overall performance by the joint analysis of X-ray and alternative EDS data.

At larger Canadian airports, carry-on baggage is subject to the following security checks:

- Baggage is screened by an X-ray machine.
- Baggage may be subject to a secondary, manual search.

Passengers are present during the security screening of their carry-on baggage. The security equipment for step 1 is usually the Heimann 6040a X-ray machine. At Canadian airports, the checked baggage is handled manually and may be transported (in part) via baggage conveyor belts.

3.3 Current Checked Baggage and Cargo Screening

A serious threat to security is the risk of incendiary or explosives attacks. Security controls on checked baggage and cargo are essential to counteract such threats. A fundamental aim of checked baggage screening is to ensure that no baggage is loaded onto an aircraft unless the passenger who checked the baggage has also boarded the aircraft. Here again, improvements in data fusion should increase effectiveness to track baggage and link it to specific passengers. This applies principally to international flights.

Checked baggage and cargo is selectively screened using the same types of technology that are in use for carry-on baggage. In this case, the primary aim is the detection of explosives. The techniques can involve X-ray imaging, vapour detection and thermal neutron analysis.

3.4 Current Ticket and Boarding-Pass Screening

Automated ticket and boarding pass (ATB) technology is becoming widespread. The ATB sometimes replaces the traditional ticket and boarding pass with a single card. Recent versions of the ATB have magnetic stripes that can be read by Boarding Control Devices (BCDs). BCDs provide real-time compilation of data such as how many people are on the flight by class of fare, where passengers are going, and where their trip originated. BCDs facilitate matching passengers to checked baggage. A major limitation in these systems is that different airlines and ticket agents use different technologies for reservation and ticketing systems.

4 INTEGRATION

This section discusses the integration of data from various security equipment or sources from the following perspectives:

- **Potential Candidates** – specific potential candidates for integration are identified and explored.
- **Opportunities** – opportunities for integration that exist today are explored.
- **Constraints** – difficulties and issues are identified that must be addressed to effect a successful implementation of an integrated system.

Figure 6 presents our conceptual selection methodology.

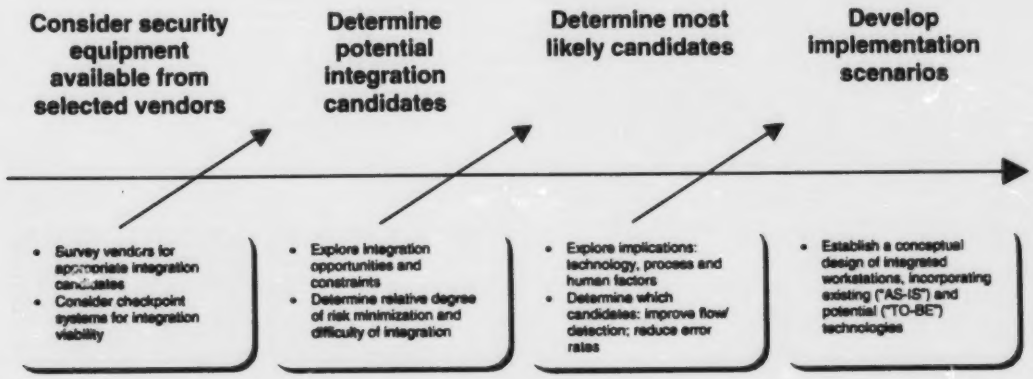

Consider security equipment available from selected vendors
Determine potential integration candidates
Determine most likely candidates
Develop implementation scenarios
• Survey vendors for appropriate integration candidates
• Consider checkpoint systems for integration viability
• Explore integration opportunities and constraints
• Determine relative degree of risk minimization and difficulty of integration
• Explore implications: technology, process and human factors
• Determine which candidates: improve flow/ detection; reduce error rates
• Establish a conceptual design of integrated workstations, incorporating existing ("AS-IS") and potential ("TO-BE") technologies

Figure 6: Selection Methodology – What we did

4.1 Available Inspection Technologies

Traditional inspection technologies have principally been applied as stand-alone mechanisms that target specific operational situations, material compounds or elements. Some industries, such as those in the nuclear arena, look for dissimilar threats using variety of inspection methodologies that are integrated with other technologies, response mechanisms and physical protections. The level and nature of integration depends on the country and the operational environment, as well as a current TRIA process.

For example, KPMG's work in the protection of nuclear sites involved combining inspection processes and technology that were significantly different from those developed for mining or jewellery manufacturing industries.

4.2 Integration Opportunities

Data integration will allow for a more efficient security process that would include the following benefits:

- improved passenger throughput;
- improved detection capabilities;
- fewer false alarms.

Through this project, we have identified examples of integration initiatives at various stages of completion. In Europe, the Heimann EDS is integrated into the checked baggage conveyor system for automated detection of explosives using X-ray technology (e.g., Nuremberg, Luten). The InVision 9000 X-ray system can be integrated with baggage handling systems (BHS) but with reduced detection performance (depending on the BHS speed).

In Rome, Perkin Elmer and L3 have teamed up to provide a system that integrates a BHS with Examiner 3dX 6000 X-ray machines. In this instance, multiple (e.g., five) X-ray machines are connected to a central control room where multiple screeners are able to view the imagery of the scanned bags as they are processed.

In Atlanta, a number of CEIA 02PN10 portals have been connected to a central station running CEIA supplied software. The software permits remote monitoring of portal status, the gathering of statistics (e.g., flow rates, alarms rates), and the remote control of portal settings (e.g., alarm thresholds). A number of Heimann 6040i X-ray machines are currently being integrated with a central station.

The following forms of data integration are also possible:

- integration between checked and carry-on baggage;
- integration with passenger profiling (for either checked or carry-on baggage);
- integration of airline check-in, carry-on baggage, passenger metal detection, and boarding gate.

As newer technologies are added to the security process (e.g., trace explosive detection systems), the need for data integration becomes more urgent to minimize the overall impact to the security process flow, passenger throughput rates and operational costs. Moreover, before these newer technologies are incorporated into the airports, their potential for data integration needs to be considered with the above objectives in mind.

Where industry is moving toward integrated solutions, the trend will be for EDS machines to communicate with airport BHS to exchange bag-specific information for tracking purposes. Some customers have indicated a future desire to integrate computer-

profiling systems with decisions (and images) collected by integrated explosives detection systems. Passenger and passenger baggage information would be collected and displayed on a single screen.

For Canadian airports, these newer technologies include the following:

- data capture and utilization for passenger profiling;
- automated baggage handling systems;
- identification tags located on bags to identify the owner (passenger);
- trace explosives detection systems;
- other forms of security that may be considered (e.g., CCTV video cameras).

In addition, there are potential upgrades to existing equipment.

4.3 Constraints

In general, current technologies are not ready for immediate integration with equipment from other manufacturers, or in many cases, with equipment from the same manufacturer. A number of technical issues must be properly addressed to achieve successful implementation of an effective security process that incorporates data integration:

- vendor support;
- equipment interfaces;
- association of data from various sources;
- sufficient funding for studies and prototypes.

4.3.1 Vendor Support

The integration capabilities of various technologies are very dependent on the philosophy of the particular manufacturer. Some manufacturers (for example, IDS) appear motivated to support equipment integration. IDS systems are designed using off-the-shelf, open-architecture hardware and operating systems. Other manufacturers (for example, CEIA) are interested in providing integration solutions for their equipment only. CEIA will feature a product that very effectively interfaces a number of 02PN10 portals with a central location; however, they will not provide information needed to interface the CEIA with other types of equipment. Other manufacturers (for example, Barringer) appear to have no integration strategy at all. Barringer will not (or cannot) supply either information or products that could be used to integrate their explosive detection systems.

To enable data integration, most of the existing and future security equipment will need to be modified or designed with integration in mind by the original manufacturers. These manufacturers must ensure that their equipment appropriately addresses the following issues:

- Provide a real-time data output of each security scan (for each bag).
- Provide a mechanism to associate each resulting security scan with unique passenger identification data.

Vendors will need to be motivated to incur the costs required to develop security equipment that is more amenable to data integration. Most vendors indicate that clear regulatory standards, support and mandates are required to provide direction to the industry to achieve these goals. Regulatory bodies may also need to clearly define the expected benefits of data integration in terms of detection rates, false alarms and passenger throughput rates.

Finally, the integration of equipment is not a trivial task. In the specific case of airport security equipment, integration is further complicated because much of the equipment was designed with no regard for integration, and because many manufacturers express little interest in integration. For these reasons, sufficient funding will be required to ensure the design and implementation of a workable integration scenario.

4.3.2 Human Security Resource Interface

A traditional weak point in most automated security systems is the human security resource. This component of the overall process fundamentally and directly affects the success of any inspection system. Specific attention to the training and ongoing operational needs of the human security resources is critical. Maximization of the human and technological components of any security program is a key element.

4.3.3 Operational Interfaces

An interface with operational equipment is important for data integration, since these interfaces would be required to extract the results of the scan of a passenger or bag. The following aspects need to be considered:

- What is the interface type: contact, serial, Ethernet, or non-standard?
- Can the data be extracted in real time without significantly interfering with the machine's original bag/passenger flow rate?
- Can the data be interpreted once extracted (e.g., is it in proprietary format)?
- Can the data be manipulated and/or analyzed by computer software? (E.g., data in the form of a VGA video capture cannot be easily manipulated, although it is not in proprietary format.)
- Can the equipment be controlled via the interface?

Extracting the data in real time is an issue with most systems, particularly as these systems were not originally designed to support this feature. While some systems support a network interface (such as Ethernet or FDDI using TCP/IP), extracting the data in real time without interrupting the flow rate is usually not feasible. This aspect will depend on the specific type of equipment being integrated.

Remote control of security equipment is in general not possible. Remote control could be used most effectively in the selection of threshold levels. It could also be used to convey information to the screener (by remotely activating an alarm, for example).

To minimize the impact on security systems and to allow maximum flexibility, a data integration system would require a "master" control computer system that would receive data from the various security sources. This system could be required to interface with the following security checkpoints:

- check-in counter (for passenger profiling data);
- checked baggage security scans;
- passenger security scans;
- carry-on baggage security scans.

Those pieces of equipment that have a binary result could use a simple interface (e.g., contact), while the more data-intensive equipment (e.g., those producing an image) would require a TCP/IP-like interface. This "master" control system would have to support both of these types of interfaces, as shown in Figure 7.

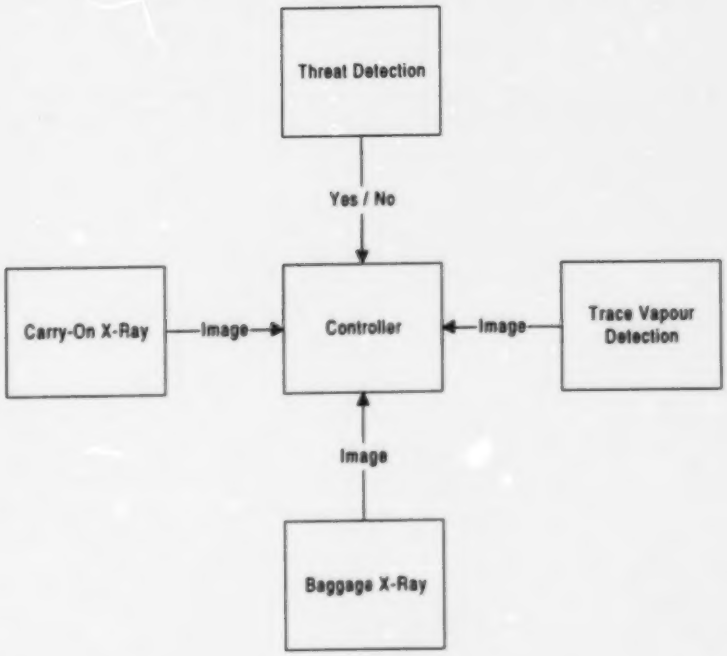


Figure 7: Interfaces

4.3.4 Data Association

The usefulness of an integrated system hinges on its ability to associate, or link, data from various sources. For example, it is necessary to identify the owner of a piece of luggage when that piece of luggage is found to contain an explosive.

As passengers and their bags pass through the various security checkpoints, the resulting security scans and passenger profiles must be linked with each passenger to achieve the full benefits of data integration. This means linking each passenger with the following:

- checked baggage security scan;
- carry-on baggage security scan;
- passenger security scan.

These links must be achieved quickly, accurately, automatically and efficiently.

One solution is to tag each bag with a radio frequency (RF) or bar-coded tag that is read by each device and associated with the resulting security scan output. These tags will uniquely identify the passenger.

The cost, complexity and impact to the overall security process must be carefully considered for any solution to this issue.

4.4 Technology Innovations

This section introduces two technological innovations pertinent to the integration of airport security at the passenger and carry-on baggage screening point.

4.4.1 Computer-Assisted Passenger Screening (CAPS)

Bag matching is a security measure in which a passenger's bags may not be transported unless the passenger is on the flight. It already is used for travellers on international flights and has been used on a limited basis for domestic flights. Expanded bag matching will be based on both computer and manual passenger screening systems during the transition to fully computerized passenger screening. Computer-Assisted Passenger Screening is used to select baggage for explosives detection examination or expanded bag matching. CAPS uses information from the reservation system to screen out passengers for whom additional security procedures are unnecessary. If not enough is known about a passenger to make a judgment, then additional security measures in the form of explosives detection device screening or bag matching is applied. CAPS will also select some passengers at random for these additional security measures.

American, Continental, US Airways, Delta, TWA and United Airlines, covering all major reservation systems, began work on developing their CAPS systems in May 1997. On February 5, 1998, United Airlines implemented CAPS at all 225 of its domestic stations (including United Express). Some other carriers have begun field testing CAPS. The FAA is helping fund these efforts through cooperative agreements, which will disburse funding appropriated by Congress for CAPS to the carriers.

As the use of CAPS expands, security improves, because CAPS offers numerous advantages over its manual alternative, including greater sophistication, speed, protection against the compromise of sensitive security information, and objectivity.

4.4.2 Trace Detection Systems

Trace explosives-detection devices (TEDDs) represent a significant portion of the current FAA deployment of explosives detection equipment. Configured first as vapour detectors, and more recently as trace (e.g., minute particles) detectors, these relatively low-cost, fixed or portable, sensitive, chemically specific devices are sometimes used for screening carry-on baggage. TEDDs are being used in the current deployment for the resolution of alarms of checked baggage from bulk explosives-detection equipment and for checking suspicious carry-on hand baggage.

The detection of trace amounts of explosives does not necessarily reveal the presence of a bomb. An alarm from a TEDD signifies the presence of vapours or particles of explosive material that can only be connected inferentially to the presence of explosives. Although TEDDs can be used to determine the type of explosive material, they cannot be, and are not, used to determine the quality of explosive material. Furthermore, trace-detection techniques may be vulnerable to unsophisticated countermeasures, and the absence of trace amounts of explosives does not guarantee that no explosive material is concealed in the bag.

5 EVALUATION OF INTEGRATION TECHNOLOGIES

The focus of this study is passenger screening and carry-on baggage screening checkpoints. The key technologies deployed at the passenger and carry-on baggage checkpoints are:

- **Portal detector**: metal detector used to detect metal on a passenger's person, typically the CEIA 02PN10 device.
- **Metal detector wand**: used to pinpoint location of metal objects carried by a passenger.
- **X-ray machine**: used to inspect carry-on baggage (including coats and other personal items carried by passengers).
- **Trace Explosives Detection Systems (TEDS)**: used to detect presence of explosive materials. While not commonly employed in Canada, TEDS' integration capabilities are being studied in anticipation of their deployment.
- **Automatic scanners**: used to scan or read boarding passes and baggage tags, can be used to ensure individuals are entitled access to boarding areas, and can be used to match passenger data with baggage data.

The primary objectives of integration are:

- **Improve Flow**: improve the overall screening process to maintain or improve passenger throughput by optimizing the following factors:
  - communication between security officers;
  - information transfer between security systems;
  - process flow of passengers;
  - process flow of baggage.
- **Improve Detection**: improve the detection rate of actual security threats by improving current technologies, potentially expanding the technology base to identify additional threats (e.g., trace explosives).
- **Reduce Error Rates**: reduce the rate of error (i.e., false positives and false negatives) by optimizing the performance of both the screeners and the screening technology.

5.1 Evaluation Against Primary Objectives

Four technologies in combination were evaluated against the primary objectives in order to reduce the field of potential integration candidates. Because automatic tag scanners are flexible, common and easy to interface, and because they are required for integration of passenger and baggage data, tag scanners were not included in the evaluation. The reduced field of potential candidates is evaluated against a set of detailed criteria in section 5.2.

Table 2: Evaluation against primary objectives

	Improve Flow	Improve Detection	Reduce Error Rates	Points
Portal/Wand	NI	NI	NI	0
Portal/X-ray	**L**	**L**	**NI**	**2**
Portal/TEDS	**M**	**L**	**NI**	**3**
Wand/X-ray	NI	NI	NI	0
Wand/TEDS	NI	NI	NI	0
X-ray/TEDS	**M**	**M**	**M**	**6**
Portal/Wand/X-ray	NI	NI	NI	0
Portal/Wand/TEDS	M	L	NI	3
Portal/TEDS/X-ray	**M**	**M**	**M**	**6**
Wand/TEDS/X-ray	M	M	M	6
Portal/Wand/TEDS/X-ray	M	M	M	6

H = High level of impact (3 points)

M = Moderate level of impact (2 points)

L = Low level of impact (1 point)

NI = No Impact (0 points)

NB: Please note that these are ranges, with the average taken.

The significant options are highlighted in Table 2. This evaluation results in the exclusion of the hand-held wand from integration, which is justified by the following:

- The hand-held wand is only used when the portal alarm is activated, and indicates whether, and where metal objects are located on a passenger.
- The hand-held wand must be operated manually. Remote monitoring of its alarm status would not be useful or practical.
- Integration of the wand with any other technology has a negligible effect on process flow, error rates and detection rates.

A caveat to this exclusion is that there may exist a hand-held wand that detects both metal and explosives. This combination wand could be used to alert the X-ray screener to scrutinize the passenger's carry-on baggage more closely.

5.2 Evaluation Against Detailed Criteria

The significant integration candidates selected from the first evaluation were then evaluated against a list of detailed criteria. The purpose of this evaluation was to define the best candidates for integration. The detailed evaluation criteria were divided into three groups: Processing, Technology Integration and Human Factors. Each candidate was scored in each category, and cumulative scores were totalled and compared.

The evaluation criteria definitions are presented in Table 3.

Table 3: Definitions of detailed criteria

Processing	
Minimizes degree of change with current technologies	Ensures that the technologies included in the integration will minimize the degree of change from the current screening technologies used in Canadian and U.S. airports.
Meets international requirements	Ensures that the technologies included in the integration will meet requirements for security screening processes by other countries and international associations
Meets operational requirements	Ensures that the technologies included in the integration will meet operational requirements of current security, airport and airline systems
Optimizes process flow	Ensures that the technologies included in the integration will optimize process flow of passengers, baggage, information and communication in the security screening process.
Technology Integration	
Uses off-the-shelf products	Ensures that the integration uses standard products that are readily available at a reasonable cost without specialized development and maintenance requirements.
Presents integrated display to the screener	Ensures that the information displayed to the security officer is integrated in a well-tested design to reduce screener overload and minimize redundant equipment.
Provides capability for data manipulation	Ensures that the system allows for the storage and analysis of security screening data (i.e., passenger or baggage information) with the flexibility to meet various future airport requirements.
Provides practical alternative	Ensures that the technologies offer a practical alternative in terms of threat reduction.
Provides cost-efficient option	Ensures the technology offers a cost-effective approach to reducing threat.
Human Factors	
Presents effective user interface for screeners	Ensures that the technology provides a clear requirement to screeners in terms of assisting in decision making, identifying threats, and interacting with displays and controls.
Presents effective user interface for passengers	Ensures that the technology provides a clear requirement to passengers in terms of proceeding through the security process, preparing for security screening, and interacting with equipment and screeners.
Considers screener issues	Ensures that the impact of the technology integration on organizational and psychosocial issues such as screener selection, training, motivation, interaction and shift structure have been considered.
Effectively allocates human/machine function	Ensures that the requirements of the machine (i.e., technologies) and the human screeners have been allocated based on human factors principles, to optimize screener workload, efficiency and threat detection reliability.
Features effective workstation layout/design	Ensures that the technology integration allows for an effective design and layout of the security screening checkpoints for both the security screening personnel and passengers, to improve comfort, efficiency and throughput.

As indicated in Table 4, the portal with TEDS has the greatest potential for integration. The other three options all have similar ratings.

Table 4: Evaluation of detailed criteria and significant options

	Portal/TEDS/X-ray	X-ray/TEDS	Portal/TEDS	Portal/X-ray
Processing				
Minimizes degree of change with current technologies	L or M*	L or M*	L or M*	L or M*
Meets international requirements	H	H	H	M
Meets operational requirements	M	M	H	M
Optimizes process flow	M	M	H	M
Technology Integration				
Uses off-the-shelf products	L or M*	L or M*	H	L or M*
Presents integrated display to the screener	L or M*	L or M*	H	L or M*
Provides capability for data manipulation	H	H	L	M or H*
Provides practical alternative	M or H*	M or H*	H	M or H*
Provides cost-efficient option	M	M	H	M
Human Factors				
Presents effective user interface for screeners	L or M*	L or M*	H	L or M*
Presents effective user interface for passengers	M	M	M	H
Considers screener issues	L	M	H	M
Effectively allocates human/machine function	H	M	M	M
Features effective workstation layout/design	M	M	H	M
Total Score	28.5	28.5	36.5	28

H = High level of compliance with detailed criteria (3 points)

M = Moderate level of compliance with detailed criteria (2 points)

L = Low level of compliance with detailed criteria (1 point)

**Score depends on the choice of vendor*

NB: Please note that these are ranges, with the average taken.

The evaluation exercise was useful in ranking candidates. However, it should be noted that scores were not weighted, which implies that each criterion carried equal weight. This may not be the case in reality. For instance, "uses off-the-shelf products" was weighted the same as "considers screener issues". There is also an inherent challenge in quantifying candidates, using essentially qualitative criteria.

The evaluation proved very useful, however, in illustrating that three of four candidates scored very closely, with the fourth scoring somewhat better than the others. An analysis of the scores yielded the following conclusions:

- Integration of the portal with a TEDS unit that analyzes passengers for explosives residue (a walkthrough unit or boarding card analyzer, for example) scored highest. This is primarily due to its effective re-use of the existing portal equipment, the comparative ease of integrating two audible alarms, and the comparatively minimal changes to current security procedures.

- The other three candidates, all of which include the X-ray, scored lower because of the risk associated with integrating and using the complex image data generated by the X-ray equipment. In the case of the X-ray and TEDS unit candidates, integration is further complicated by the difficulty in analyzing carry-on items for explosives.

- The appearance of a new product on the market could significantly alter the evaluation scores. There are several explosives detection devices currently in development and some of these could have a significant impact on the integration of explosives detection with X-ray or with metal detection. For example, a portal capable of performing both metal detection and trace explosives detection is in development by IDS. This unit is discussed in section 6.

6 INTEGRATION CAPABILITIES OF EQUIPMENT

The four technologies identified in the significant integration options in the previous section are described in detail in this section with reference to actual equipment. Each piece of equipment, referred to as an integration candidate, is then evaluated. This analysis provides the basis for definition of equipment integration scenarios in section 7.

Both current scenarios incorporating existing technology ("Base" scenarios) and "Expanded" scenarios featuring potential and planned equipment were considered. With the latter type, conceptual innovations and how they affect process and overall security were also considered.

6.1 Integration Candidates

Canadian airports have not yet standardized on an explosives detector, so a range of equipment types are presented. Because Canadian airports have standardized on a portal (CEIA 02PN10) and a X-ray machine (Heimann 6040), and because the Atlanta airport integration team recently chose these types of portal and X-ray, only these select equipment types are presented.

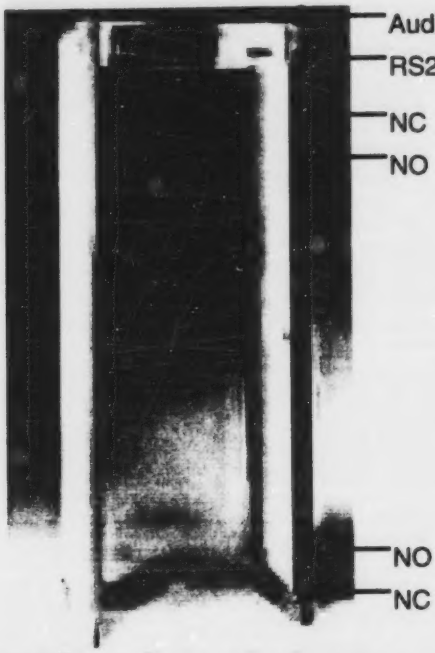
The equipment presented in sections 6.1 (Figures 8 through 19) and 6.2 is divided into two groups: the BASE vendor candidates and the EXPANDED technology group (which also includes advanced technologies such as biometrics). The BASE vendor candidates are those which are both commercially available and suitable for integration. The BASE vendor candidates are:

- Metal Detection: CEIA 02PN10.
- X-Ray: Heimann 6040a, Heimann 6040i.
- Explosives Detection: InVision QScan QR160, IDS Orion.
- Baggage and Passenger Identification: bar-code tagging, radio frequency (RF) tagging.

The BASE vendor candidates were evaluated against a set of detailed criteria, as defined in section 6.3.1. Candidates were evaluated and assigned scores, as shown in sections 6.3.2 and 6.3.3.

6.1.1 CEIA 02PN10 (Metal Detection)

- Integrate by serial connection (RS232) or by alarm contacts.
- Passenger walks through the portal opening. An alarm is generated if the level of metal detected exceeds a pre-determined threshold.



Dimensions:
87.5 x 68 x 223.5 (cm)

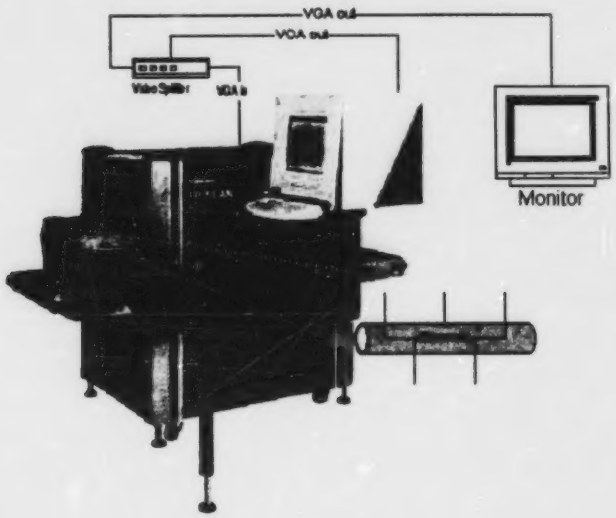
CEIA 02PN10 Integration Capabilities

	RS232	Contact
Data output	Alarm indication Status (e.g., thresholds)	Alarm indication
Data input	Control data (e.g., thresholds, settings)	None
Hardware required	Windows-based PC with Ethernet card	Indicator or PLC or PC with interface card
Software required	CEIA supplied custom software	None
Notes	Atlanta: 29 portals integrated. CEIA s/w cannot be integrated.	

Figure 8: CEIA 02PN10

6.1.2 Heimann 6040 (X-ray)

- Integrate 6040a by video splitting.
- 6040a can be upgraded to 6040i to provide sophisticated, vendor-supported integration capabilities via Ethernet.
- Carry-on items are placed on a conveyor belt and X-ray images of the items are analyzed by trained screeners.
- Suspect items are hand-searched.



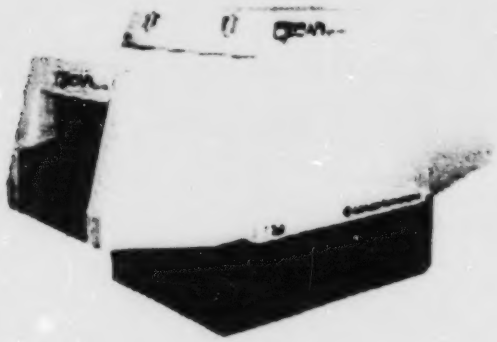
Heimann 6040a, 6040i Integration Capabilities

	Video Splitter	Ethernet
Data output	VGA signal	"Bag" images, status
Data input	None	Control data
Hardware required	Video splitter (e.g., Hall Research Model 210-LP), monitor, extension cable	PC with Ethernet card, upgrade of 6040a to 6040i
Software required	None	PC communication and GUI software
Notes	Cable length up to 150 ft.	Integration at Atlanta airport; Vendor will support; Software may be available.

Figure 9: Heimann 6040

6.1.3 InVision QScan QR160 (TEDS)

- Integrate by alarm contact or by accessing locally stored data via Ethernet.
- Passenger carry-on items are scanned in a manner similar to X-ray scanning.



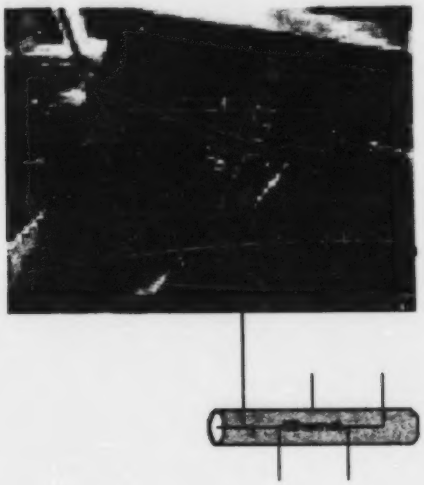
InVision Qscan QR160 Integration Capabilities

	Ethernet	**Contact**
Data output	Retrieve data stored on local Pentium hard disk	Alarm indication
Data input	Unknown	None
Hardware required	Windows-based PC with Ethernet card	Indicator or PLC or PC with interface card
Software required	Software development required	None
Notes	Product has an internal PC using QNX real-time operating system.	

Figure 10: InVision Qscan QR160

6.1.4 IDS Orion Plus (TEDS)

- IDS appears interested in supporting integration of their products. Literature implies integration should be low risk.
- Integrate by alarm contact or by Ethernet.



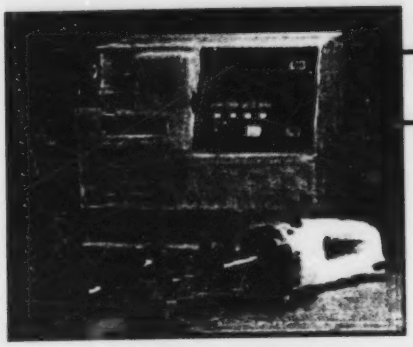
IDS Orion/Orion Plus Integration Capabilities

	Ethernet	Contact
Data output	Data and control parameters	Alarm indication
Data input	Control parameters	None
Hardware required	Windows-based PC with Ethernet card	Indicator or PLC or PC with interface card
Software required	Software development required	None
Notes	Vendor claims integration is possible and straightforward.	

Figure 11: IDS Orion Plus

6.1.5 Barringer Ionscan 400B (TEDS)

- Integrate by alarm contact or by using Barringer's Remote Monitoring tool.
- Remote monitoring is designed to give Barringer access to installed equipment to aid in trouble shooting and support. Software could be modified for integration. Data exchange is not real-time.
- Operation is similar to IDS Orion.



Barringer Ionscan 400B

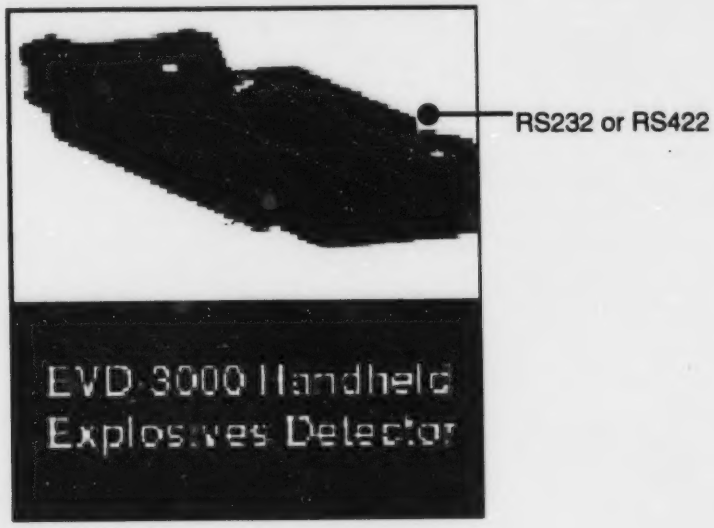
Barringer Ionscan 400B Integration Capabilities

	Serial (modem) link	**Contact**
Data output	Alarm indications Status (e.g., thresholds)	Alarm indication
Data input	Control data (e.g., thresholds, settings)	None
Hardware required	Windows-based PC with Modem	Indicator or PLC or PC with interface card
Software required	Barringer supplied custom software, which would require custom modification	None
Notes	Vendor indicated willingness to share serial communication protocol, but then reneged.	

Figure 12: Barringer Ionscan 400B

6.1.6 IDS EVD3000 (TEDS)

- Integrate by serial interface.
- Hand-held unit requires a 5-10 second sampling time and a 10-second analysis time.
- This product is currently available and there are no plans to discontinue it.



IDS EVD3000 Handheld TEDS Integration Capabilities

	Serial
Data output	Alarm and measurement data
Data input	Unknown
Hardware required	Host computer
Software required	Customized software on host computer likely required.
Notes	Vendor appears eager to assist with integration.

Figure 13: IDS EVD3000

6.1.7 IDS NOVA Walkthrough (Metal Detection and/or TEDS)

- Integrate by Ethernet or by alarm contacts.
- Passenger walks through portal opening, pausing in portal for a few seconds. An alarm is generated if the level of metal or explosives detected exceeds a pre-determined threshold.

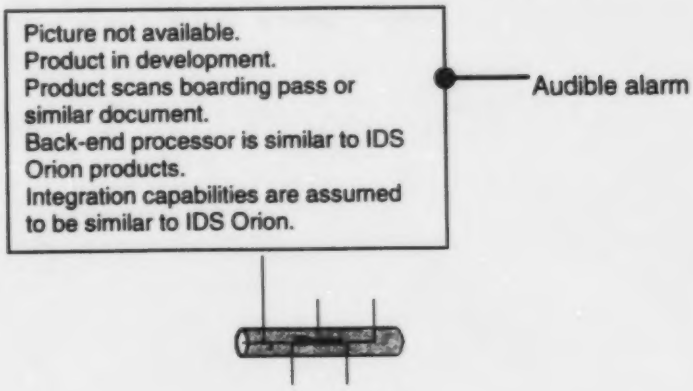
Dimensions:
slightly larger than CEIA portal
(CEIA portal shown)

IDS NOVA Walkthrough Integration Capabilities

	Ethernet	Contact
Data output	Audible alarm, compound identification, threshold setting	Alarm indication
Data input	Control data (e.g., thresholds, settings)	None
Hardware required	Windows-based PC with Ethernet card	Indicator or PLC or PC with interface card
Software required	IDS will supply communication specifications and software.	None
Notes	Product has an internal PC with QNX operating system.	

Figure 14: IDS NOVA Walkthrough

6.1.8 IDS/Sciex Boarding Pass Scanner (TEDS)


Picture not available.
Product in development.
Product scans boarding pass or similar document.
Back-end processor is similar to IDS Orion products.
Integration capabilities are assumed to be similar to IDS Orion.
Audible alarm

IDS/Sciex Boarding Pass Scanner Integration Capabilities

	Ethernet	Contact
Data output	Data and control parameters	Alarm indication
Data input	Control parameters	None
Hardware required	Windows-based PC with Ethernet card	Indicator or PLC or PC with interface card
Software required	Software development required	None
Notes		

Figure 15: IDS/Sciex Boarding Pass Scanner

6.1.9 Barringer Document Scanner (TEDS)

- Barringer has no plans to take the product to market (verbal communication with Paul Kennedy, April 6, 2000).
- Assumption made that an alarm contact could be integrated.
- A passenger-handled piece of paper (e.g., boarding pass) is swiped over the scanner. Results are returned in 6 seconds.

Barringer Doc Scanner

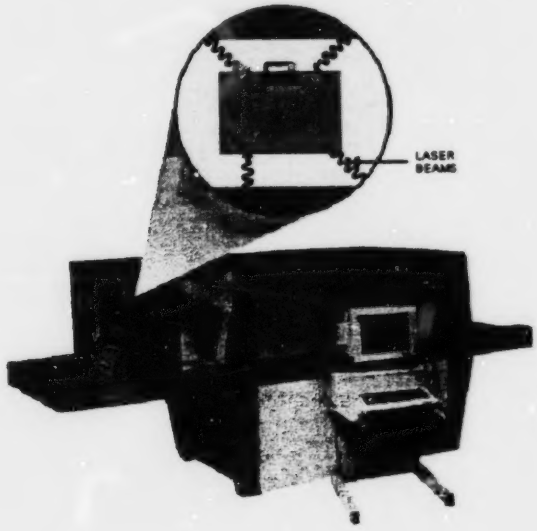
Barringer Doc Scanner Integration Capabilities

	Ethernet	**Contact**
Data output	Alarm indication Possibly status	Alarm indication
Data input	Unknown	None
Hardware required	Unknown	Indicator or PLC or PC with interface card
Software required	Unknown	None
Notes	High risk. Information not available.	The audible alarm contact can be used.

Figure 16: Barringer Document Scanner

6.1.10 IDS Laser Detector (TEDS)

- Product is currently under development by IDS in cooperation with TDC.
- Literature claims that the product can be integrated with baggage X-ray machines.



http://www.tc.gc.ca/tdc/r&d/v9n1.htm

Barringer Doc Scanner Integration Capabilities

Data output	Unknown
Data input	Unknown
Hardware required	Unknown
Software required	Unknown
Notes	Literature states integration with existing X-ray systems is possible.

Figure 17: IDS Laser Detector

6.1.11 Radio Frequency Tags

- Integrate by serial interface, or can be wireless.
- Up to 170 bytes of data can be stored (storage capacity is expected to increase).
- Units can both read and write data to the RF tags.
- Tag must pass in the vicinity of the scanner, but the scanner does not require an unobstructed view of the tag.

Radio Frequency Scanner/Writer Integration Capabilities

	Serial
Data output	Encoded data, bar code data (optional)
Data input	Write data
Hardware required	Host computer
Software required	Inventory type software is readily available. Customized software is an option.
Notes	Hand-held, wireless LAN, and mounted units are available. There are many vendors.

Figure 18: RF Tags

6.1.12 Bar-Code Tags

- Integrate by serial interface, or can be wireless.
- Requires tie-in with airline database to decode bar code.
- Bar code must pass in close proximity to scanner.

RS232 or RS422

Bar-Code Scanner Integration Capabilities

	Serial
Data output	Bar code image
Data input	Display data (optional)
Hardware required	Host computer
Software required	Inventory type software is readily available. Customized software is an option.
Notes	Hand-held, wireless LAN, and mounted units are available. There are many vendors.

Figure 19: Bar-Code Tags

6.2 Equipment Summary

The integration capabilities of each piece of equipment are summarized in Table 5 under the following headings:

- **Risk level**: a qualitative evaluation of the risk associated with including the equipment in an integration scenario. Data presented in the table substantiates the evaluation.

- **Advantages**: characteristics of the equipment or the vendor that tend to lessen the risk associated with integrating; characteristics of the equipment or vendor that have a favourable impact on the key integration criteria.

- **Disadvantages**: characteristics of the equipment or the vendor that tend to increase the risk associated with integrating; characteristics of the equipment or vendor that have a negligible or negative impact on the key integration criteria.

- **Notes**: any additional information.

Table 5: Summary of integration candidates

Vendor and Identification	Risk Level	Advantages	Disadvantages	Notes
CEIA 02PN10	Low	• CEIA alarm contacts can be easily integrated with other systems. • Individual CEIA 02PN10 portals can be easily connected over a serial interface to a central station running CEIA software. This software allows remote monitoring, control and collection of statistics. • Widely used in Canada. • Recently installed and linked to a central station at the Atlanta airport.	• Integration of CEIA alarms with X-ray equipment or with TEDS equipment that inspects baggage is not useful. • The vendor will not share information about its serial interface. This may preclude sophisticated integration of the CEIA 02PN10 with equipment from other manufacturers.	• The vendor would consider customizing its software for a particular application. The vendor is interested only in providing the complete integration solution.
IDS NOVA Walkthrough	Medium to High	• Easy to use – similar to magnetic detector passenger portal. • Has an RS-232 interface for remote operation. • The audible alarm contacts can be used for a simple alarm status interface. • Excellent integration capabilities. • Can be enhanced to include magnetic detection, video capture, drug detection, electronic device detection and radiation detection.	• Product not available until first quarter of 2001. • May have negative impact on throughput. • Performance specifications, including detection capabilities, are not known.	• Vendor is motivated to support integration. Unit is designed using off-the-shelf, open-architecture computer hardware and operating systems.
InVision QScan QR160	Medium	• Easy to use – similar to X-ray scanner, with pass/fail decision. • Impacts on passenger flow and throughput are minimal: scan rate of 500 bags/hour. • Claims precision capabilities equal to trace detection. • Successfully employed in non-airport security environments. • Excellent choice for integration with X-ray machine: alarm contact can be easily integrated, and analysis data can be extracted. • Impacts on throughput and passenger flow are minimal.	• Detection capabilities (limited to primarily to plastic explosives) may limit usefulness. • Has a large footprint.	• Internal PC runs QNX operating system. • Analysis result is a single number that is compared to a threshold. Alarm contacts are activated if the threshold is exceeded. Analysis results are stored internally and can be accessed via Ethernet. • Requires airport trials to confirm operation.
Barringer Document Scanner	High	• Easy to install and use – a passenger-handled document is scanned for trace explosives. • The document scanner was developed under contract to the FAA.	• Product is not market ready. • Integration capabilities are undefined. • Detection capabilities unknown.	• The document scanner is a one-off product developed for the FAA for testing purposes. • Transport Canada and Barringer have discussed ticket toaster concepts, but the product does not exist. • Because products are not available for market, specification of interfaces is not possible.
Barringer Ionscan 400B	Medium to High	• Vendor expressed willingness to share serial interface protocol and specifications. • The audible alarm contacts can be used for a simple alarm status interface. • Successfully employed in security environments.	• Sampling and analysis time requirements could severely affect throughput and/or passenger flows. • Integration of more than alarm indication potentially costly and difficult.	• There is a risk associated with trusting the verbal assurance that the specification will be provided. • Requires manual wiping of baggage with special cotton swab and analysis of the swab – manually intensive and slow. • There are very similar systems available from competing companies.
IDS Orion/Orion Plus	Low	• Successfully employed in security environments. • Has an Ethernet connection for integration. • Vendor is motivated to support integration. • Unit is designed using off-the-shelf, open-architecture computer hardware and operating system.	• Sampling and analysis time requirements could severely affect throughput and/or passenger flows.	• Collection of sample is slow and manually intensive. • Analysis of the collected sample takes up to 30 seconds.

Vendor and Identification	Risk Level	Advantages	Disadvantages	Notes
IDS / Sciex Boarding Pass Scanner	High	• Easy to use and install - a passenger-handled document is scanned for trace explosives. • Uses a proven "back-end" analyzer (based on IDS Orion). • Vendor is motivated to support integration. • Unit is designed using off-the-shelf, open-architecture computer hardware and operating systems.	• Product is in development stage. • Analysis time requirements could affect throughput and passenger flow.	• The product is not currently on the market. No forecast of availability could be found. • Analysis of the scanned document could take up to 30 seconds.
IDS EVD 3000	Medium	• Easy to use – similar to a hand-held metal detection wand, but is used on luggage or parcels. • Has an RS-232 connection that allows remote monitoring. • Audible alarm contacts could be used for a simple alarm status interface.	• Maturity of product unknown. • Sampling is manually intensive and could affect throughput and passenger flow. • Integration capabilities unclear.	• Status of field implementations unknown. • Sample time is 5-10 seconds, analysis time is 10 seconds.
IDS Laser Detection Systems	High	• Excellent choice for integration with X-ray machine. • Use is transparent to passengers. • Fast sampling and analysis. • Results are easy to interpret. • Throughput and passenger flow impacts are expected to be minimal. • Vendor is motivated to support integration.	• Product is in early stages of development and may not be market ready for several years. • Performance specifications, including detection capabilities, are unknown.	
Radio Frequency Tags	Medium	• Great flexibility. • Reduced error rate due to tag position or orientation as compared to bar codes. • Could store significant passenger data.	• Products are relatively new to market and are in a stage of rapid feature and performance enhancement. • Tags are expensive compared to bar-code tags. • May have significant impact on check-in procedures for persons travelling without checked baggage.	
Bar-Code Tags	Low	• Inexpensive to implement and use. • Many commercial systems are available that offer easy integration. • Compatible with existing bar-code tagging of checked baggage.	• Low flexibility. • Potential for errors due to stricter requirements for tag position or orientation. • Requires interface to a database supplying passenger and flight information. • May have significant impact on check-in procedures for persons travelling without checked baggage.	
Heimann 6040a	High	• Widely used in Canada.	• Integration not vendor supported. • High engineering risk and cost (if more than a remote monitor is desired): capture of video, identification of bag start and stop requires custom software. • Low flexibility: difficult to capture and analyze images; synchronization of passenger data from other systems is also difficult.	• Vendor-supported integration will require upgrade to the 6040i at a per-unit cost of less than CAD $25,000. • Integration of the 6040a would be accomplished with a video splitter, feeding 6040a video to a remote (<150 ft. away) monitor.
Heimann 6040i	Medium	• Chosen as the X-ray machine for the Atlanta airport integration, along with the CEIA 02PN10. • Atlanta integration data could be re-applied, reducing engineering costs. • Effective passenger processing. • Effective provision of information. • Minimal impacts on workspace redesign.	• Capabilities of integration are not clear.	• The 6040a can be upgraded to the 6040i for a cost of about CAD $25,000.

6.3 Evaluation Criteria Definitions

In this section, each of the BASE integration candidates was evaluated against both technical and human factors criteria. Candidates are grouped by technology in the tables. The evaluation criteria are defined as follows.

■ Engineering cost	Reflects costs associated with engineering required to use vendor's product. Costs could include software design and development, power system design, and equipment layout design. A "5" score means there are no engineering costs; the product simply needs to be purchased and "plugged-in". A "0" indicates significant design work, including prototyping, custom hardware and software design, and development and testing.
■ Equipment cost	Reflects costs associated with purchase of vendor's equipment and with peripheral equipment required for the integration. A "5" score means there are no equipment costs; a "0" indicates that the equipment is prohibitively expensive.
■ Engineering risk	Reflects degree of risk associated with using vendor's equipment, alone or in the combination specified. A "5" score means that the equipment has been successfully used in exactly the manner proposed. A "0" indicates that there is no belief that the equipment could function as proposed.
■ COTS solution	Ensures that integration uses standard products which are readily available without specialized development and maintenance requirements.
■ Proven solution	Related to engineering risk (above), this indicates the degree to which the equipment has been used in the manner proposed.
■ Compliance with EXPANDED plan	Reflects ability of equipment to function effectively in a fully integrated airport.
■ Re-use of installed equipment	Indicates degree of equipment re-use. Re-use is seen as beneficial in that it reduces costs and risks.
■ Maintenance costs	Indicates relative costs associated with maintaining the equipment.
■ Flexibility	Indicates degree to which equipment can be reconfigured for use in other scenarios.
■ Expandability	Indicates degree to which equipment can be enhanced to improve operability, speed and other performance measures.
■ Integrated display	Ensures that information displayed to security officer is integrated in a well-tested design to reduce screener overload and minimize redundant equipment.
■ Capability for data manipulation	Reflects ability to transfer data between systems, as well as potential to extract critical data elements for analysis.
■ Presents effective user interface for screeners	Ensures that technology provides a clear requirement to screeners in terms of assisting in decision making, identifying threats, and interacting with displays and controls.

■ Presents effective user interface for passengers	Ensures that technology provides a clear requirement to passengers in terms of proceeding through the security process, preparing for security screening, and interacting with equipment and screeners.
■ Effective workstation layout/design	Ensures that technology integration allows for an effective design and layout of the security screening checkpoints for both the security screening personnel and passengers, to improve comfort, efficiency and throughput.
■ Optimized user cognitive requirements for screeners	Refers to ability to present clear, accurate information to the screener. Images and other types of data must be easily understandable to the screener for the process to be effective.
■ Optimized user cognitive requirements for passengers	Refers to ability to make information easily understandable for passengers, and may include displays, signage and universality of symbols used.
■ Training requirements	Individual pieces of security equipment may have varying levels of training, certification and ongoing training to ensure that screening personnel are adequately prepared for the tasks that await them.

Tables 6 through 11 consider pairs of integration candidates and their relative rating in terms of Technology and Human Factors. The weighting of each criteria was determined by the TDC project team, which significantly affects final scores. The relative weighting is reflected in the Weighting Multiple column, with the highest three weightings being multiplied by 4, 3 and 2, respectively. All criteria without weighting multiples were added to the total scores.

Table 6: TEDS technology evaluation: InVision QScan QR160 and IDS Orion

	Weighting Multiple	InVision QScan QR160	IDS Orion
Technology			
Engineering cost	4	4	3
Equipment cost	3	3	3
Engineering risk		4	3
COTS solution		4	4
Proven solution		3	4
Compliance with EXPANDED plan		3	2
Re-use of installed equipment		4	4
Maintenance costs	2	2	1
Flexibility		3	3
Expandability		4	3
Integrated display		3	3
Capability for data manipulation		4	4
Technology Scores		***41***	***37***
Weighted Scores		***61***	***53***

Scoring: 0=Poor, 5=Excellent; Costs: 0=Significant Cost, 5=Low Cost

Table 7: TEDS human factors evaluation: InVision QScan QR160 and IDS Orion

	Weighting Multiple	InVision QScan QR160	IDS Orion
Human Factors			
Effective user interface for screeners	4	3	2
Optimized user cognitive requirements for screeners		3	2
Effective user interface for passengers	3	4	2
Optimized user cognitive requirements for passengers		3	3
Effective workspace design		3	2
Training requirements	2	3	2
Human Factors Scores		***19***	***13***
Weighted Scores		***39***	***25***

Scoring: 0=Poor, 5=Excellent

Table 8: Identification technology evaluation: RF and Bar-Code Tags

	Weighting Multiple	Radio Frequency Tags	Bar-Code Tags
Technology			
Engineering cost	4	3	4
Equipment cost	3	3	4
Engineering risk		3	5
COTS solution		4	5
Proven solution		4	5
Compliance with EXPANDED plan		5	4
Re-use of installed equipment		0	4
Maintenance costs	2	3	4
Flexibility		5	2
Expandability		4	3
Integrated display		4	4
Capability for data manipulation		5	3
Technology Scores		***43***	***47***
Weighted Scores		***61***	***71***

Scoring: 0=Poor, 5=Excellent; Costs: 0=Significant Cost, 5=Low Cost

Table 9: Identification human factors evaluation: RF and Bar-Code Tags

	Weighting Multiple	Radio Frequency Tags	Bar-Code Tags
Human Factors			
Effective user interface for screeners	4	4	3
Optimized user cognitive requirements for screeners		4	3
Effective user interface for passengers	3	4	3
Optimized user cognitive requirements for passengers		4	3
Effective workspace design		4	4
Training requirements	2	3	4
Human Factors Scores		***23***	***20***
Weighted Scores		***46***	***39***

Scoring: 0=Poor, 5=Excellent

Table 10: X-ray technology evaluation: Heimann 6040a and Heimann 6040i

	Weighting Multiple	Heimann 6040a	Heimann 6040i
Technology			
Engineering cost	4	1	4
Equipment cost	3	4	2
Engineering risk		1	4
COTS solution		1	5
Proven solution		1	4
Compliance with EXPANDED plan		2	4
Re-use of installed equipment		4	3
Maintenance costs	2	2	4
Flexibility		1	4
Expandability		1	4
Integrated display		2	4
Capability for data manipulation		1	4
Technology Scores		***21***	***46***
Weighted Scores		***34***	***66***

Scoring: 0=Poor, 5=Excellent; Cost: 0=Significant Cost, 5=Low Cost

Table 11: X-ray human factors evaluation: Heimann 6040a and Heimann 6040i

	Weighting Multiple	Heimann 6040a	Heimann 6040i
Human Factors			
Effective user interface for screeners	4	2	4
Optimized user cognitive requirements for screeners		2	4
Effective user interface for passengers	3	3	3
Optimized user cognitive requirements for passengers		3	3
Effective workspace design	2	3	4
Training requirements		3	4
Human Factors Scores		**16**	**22**
Weighted Scores		**31**	**44**

Scoring: 0=Poor, 5=Excellent

6.4 Integration Capabilities Conclusion

The results of the equipment study and evaluation are summarized in Table 12.

Table 12: Evaluation summary

Technology	Equipment	Technology Score	Human Factors Score	Total Score	Total Weighted Score
Explosives Detection	InVision QScan	41	19	60	100
	IDS Orion	37	13	50	78
X-Ray	Heimann 6040a	21	16	37	65
	Heimann 6040i	46	22	68	110
Tagging	RF Tags	43	23	66	107
	Bar-Code Tags	47	20	67	110

The following conclusions can be made:

- The high scores (QScan, 6040i, RF/Bar-code tags) are very similar, indicating that these types of equipment will be the best selection for their integration capabilities.
- The InVision QScan scored significantly higher than the IDS Orion system. This is because:
  - The QScan has a processing rate that matches the X-ray machine.
  - The QScan is easy for both passenger and screener to use.
  - The QScan provides easily interpretable results.
  - The QScan data and alarm indications can be accessed for integration.

  The major advantage of the IDS Orion is its ability to detect a wider range of explosive materials.
- The Heimann 6040i scored significantly higher than the Heimann 6040a, mainly because:
  - The vendor will not support 6040a integration.
  - The 6040i is integrated in Atlanta.
  - The 6040i has a standard interface.
- Although RF tags and Bar-code tags scored almost equally, they have very different advantages and disadvantages:
  - RF tags offer by far the most flexibility and expandability.
  - Bar-code tags are less expensive, permit equipment re-use, and are a more mature product. Many major airports/airlines use bar-code printers for checked baggage. These could also be used to create carry-on baggage tags and boarding passes.

7 BASE CONCEPTUAL DESIGN

Based on the information presented in previous sections, a conceptual design of a security complex was undertaken by the engineering and process analysis members of our team. The conceptual design process involved integrating identified technologies to present an integrated screening environment, as well as methods to improve communications between supervisory and screening personnel.

The BASE vendor candidates presented and evaluated in the previous section are combined in a series of potential integration scenarios. These scenarios, grouped by technology integration are as follows:

- Metal and Explosives Detection Integration scenario, using:
  - CEIA 02PN10 and InVision QScan QR160 (Figure 20);
  - CEIA 02PN10 and IDS Orion Plus (Figure 21).
- Metal and X-Ray Detection Integration scenario, using:
  - CEIA 02PN10 and Heimann 6040i (Figure 22).
- Explosives and X-Ray Detection Integration scenario, using:
  - Heimann 6040i and InVision QScan QR160 (Figure 23);
  - Heimann 6040i and IDS Orion Plus (Figure 24).
- X-Ray/Metal/Explosives Detection Integration scenario, using:
  - Heimann 6040i and IDS Orion Plus and CEIA 02PN10 (Figure 25);
  - Heimann 6040i and InVision QScan QR160 and CEIA 02PN10 (Figure 26).

7.1 Metal and Explosives Detection Integration Scenario

7.1.1 CEIA 02PN10 and InVision QScan QR160

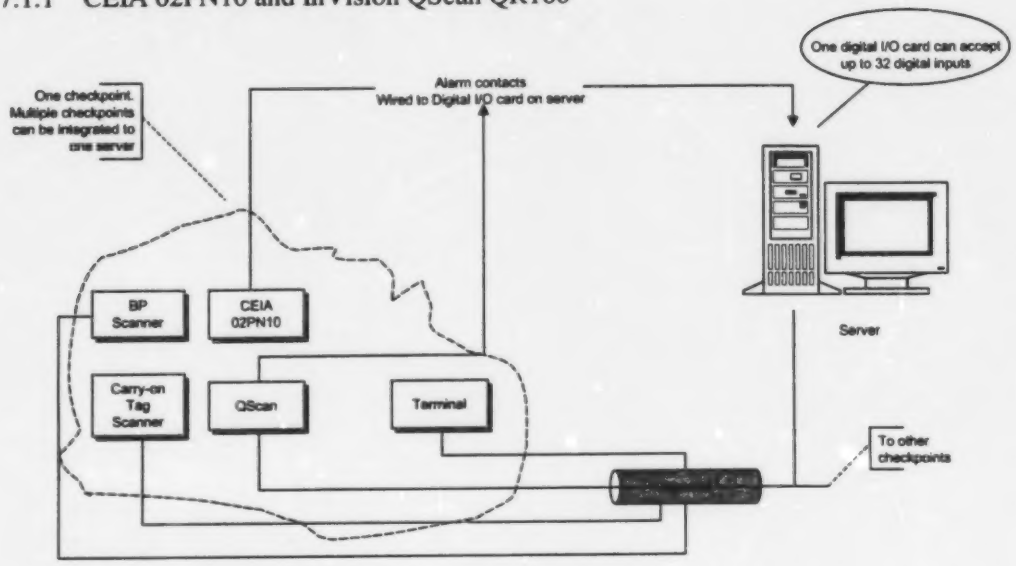

One digital I/O card can accept up to 32 digital inputs
Alarm contacts Wired to Digital I/O card on server
One checkpoint. Multiple checkpoints can be integrated to one server
BP Scanner
CEIA 02PN10
Carry-on Tag Scanner
QScan
Terminal
Server
To other checkpoints

Figure 20: CEIA 02PN10 and InVision QScan QR160

- Usage notes
  - Boarding pass is scanned at portal, for identification purposes only (not an explosive vapour sensor).
  - Carry-on item tags are scanned at QScan.
  - Passenger identification (for example, name and flight) and results of portal scan and explosive scan are displayed on a terminal.
- Integration
  - Alarm contact of CEIA is connected to a server.
  - Alarm contact of QScan is connected to a server.
  - Boarding pass and carry-on item scanners (one at each of CEIA and QScan) are connected to a server.
  - Custom software on server associates alarms with scanned tags, and communicates with Airline Systems to establish passenger identification.
  - Custom software on server sends scanning results to terminal.

- Equipment
  - InVision QScan QR160, one per checkpoint.
  - Computer configured as server, one per n checkpoints.
  - Terminal, one per checkpoint.
  - Boarding pass and carry-on item bar-code scanners, two per checkpoint.
- Enhancements
  - Connect QScan to server through Ethernet. When QScan raises alarm, detection data can be accessed by server from QScan, then displayed on terminal.
  - Use RF tag technology instead of bar-codes. Passenger data could be stored on RF tag, eliminating need to interface server with airline database.
  - The terminal displays text only; it could be a hand-held, wireless unit (although manual entry of passenger data, if needed, would then be inefficient).
  - Custom software on server could keep track of passenger flows, false alarm rates, etc.
- Human Factors / Process Implications
  - Ensures effective passenger processing and provision of information.
  - Provides integrated interface for both detection technologies to security officer.
  - Requires perception of an alarm and identification of its source before a decision can be made.
  - Minimizes impact on workspace design.

7.1.2 CEIA 02PN10 and IDS Orion Plus

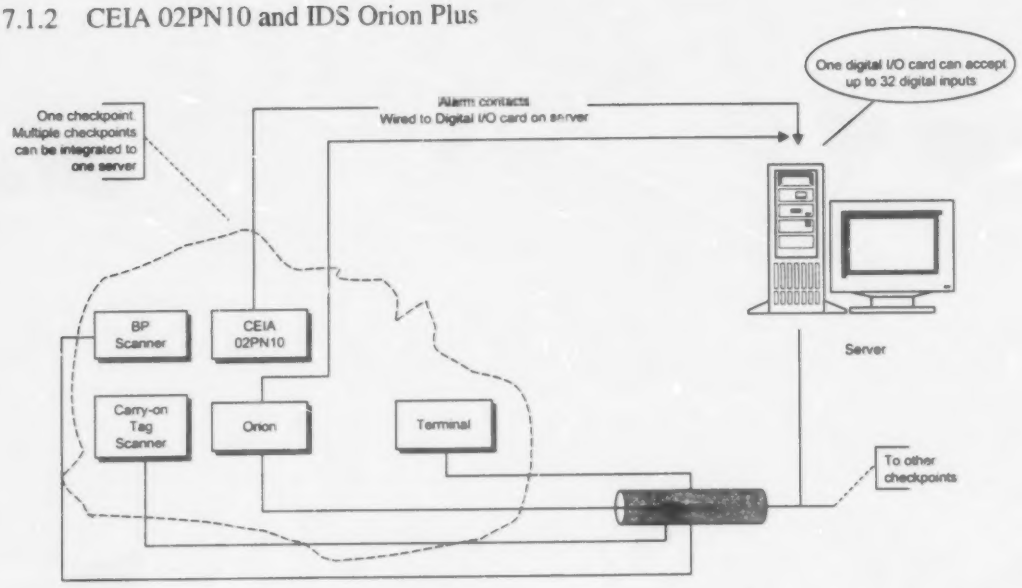


Figure 21: CEIA 02PN10 and IDS Orion Plus

- Usage Notes
  - Boarding pass is scanned at portal.
  - Carry-on item tags are scanned at Orion.
  - Passenger identification (for example, name and flight) and results of portal scan and explosive scan are displayed on a terminal.
  - Total Orion sampling and processing time is approximately 60 seconds (processing time alone is approximately 30 seconds).
- Integration
  - Alarm contact of CEIA is connected to a server.
  - Alarm contact of Orion is connected to a server.
  - Boarding pass and carry-on item scanners (one at each of CEIA and Orion) are connected to a server.
  - Custom software on server associates alarms with scanned tags, and communicates with Airline Systems to establish passenger identification.

- Equipment
  - IDS Orion or Orion Plus.
  - Computer configured as server, one per *n* checkpoints.
  - One terminal is used per checkpoint and displays text. A handheld, wireless unit may also be used.
  - Boarding pass and carry-on item bar-code scanners, two per checkpoint.
- Enhancements
  - Feedback from server to terminal (e.g., through CAPS), highlighting individual passengers who should be subjected to explosives detection. Orion sampling and analysis times will prohibit scanning all passengers.
  - Multiple Orion units for each checkpoint. This would permit parallel sampling, and could allow for 100% scanning for explosives.
  - Use RF tag technology instead of bar codes. Passenger data could be stored on RF tag, eliminating need to interface server with airline database.
  - Use CEIA serial interface to server.
  - Custom software on server could keep track of passenger flows, false alarm rates, etc.
- Human Factors / Process Implications
  - Sampling times will greatly affect baggage and passenger throughput, particularly when a passenger has difficulty understanding the process.
  - The passenger must be well-aware of the process, preferably in advance of approaching the security checkpoint (relay peak/valley).

7.2 Metal and X-Ray Detection Integration Scenario

7.2.1 CEIA 02PN10 and Heimann 6040i

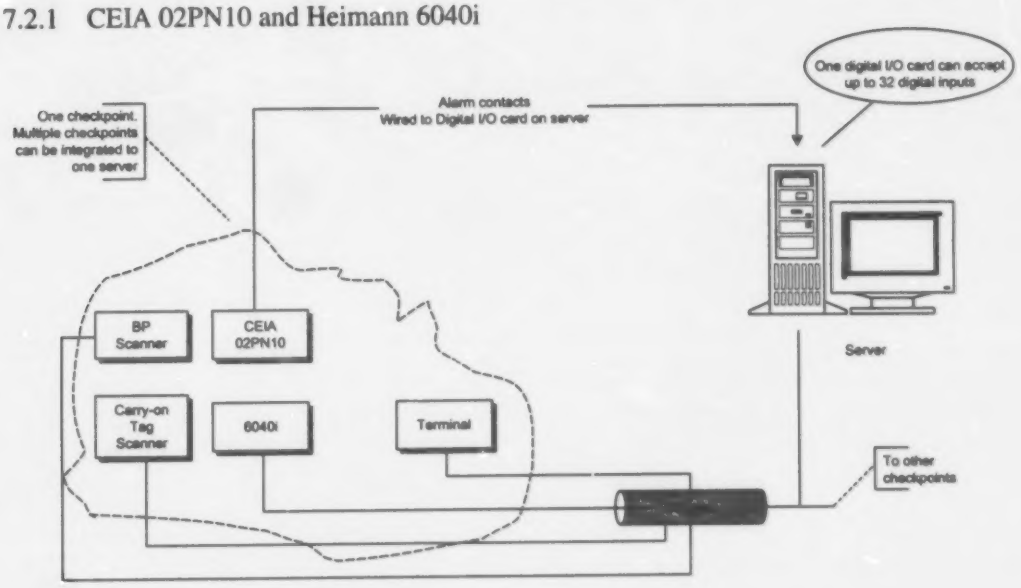


Figure 22: CEIA 02PN10 and Heimann 6040i

- Usage notes
  - Boarding pass is scanned at portal.
  - Carry-on item tags are scanned at X-ray.
  - Passenger identification (for example, name and flight) and results of portal scan and X-ray images are displayed on a terminal at checkpoint.
- Integration
  - Alarm contact of CEIA is connected to a server
  - 6040i is connected to a server over Ethernet, providing image data and control capability.
  - Boarding pass and carry-on item scanners (one at each of CEIA and X-ray) are connected to a server.
  - Custom software on server associates alarms and X-ray image(s) with scanned tags, and communicates with Airline System to establish passenger identification data.
  - Custom software on server displays images and scanning results at terminal.

- Equipment
  - Heimann 6040i, one per checkpoint (6040a can be upgraded to 6040i).
  - Computer configured as server, one per n checkpoints.
  - Terminal, one per checkpoint (in addition to the display on the 6040i).
  - Boarding pass and carry-on item bar-code scanners, two per checkpoint.
- Enhancements
  - Use RF tag technology instead of bar codes. Passenger data could be stored on RF tag, eliminating need to interface server with airline database.
  - Use CEIA serial interface to server.
  - Custom software on server could keep track of passenger flows, false alarm rates, etc.
- Human Factors / Process Implications
  - Ensures effective passenger processing and provision of information.
  - Provides integrated interface to security officer.
  - Minimizes impact on workspace design requirements.
  - Requires security officers to make decisions as to how to respond to passenger information.

NOTE: Integration between the CEIA and Heimann 6040a was not evaluated, given that there is no effective way to access the necessary data from the 6040a.

7.3 Explosives and X-Ray Detection Integration Scenario

7.3.1 Heimann 6040i and InVision QScan QR160

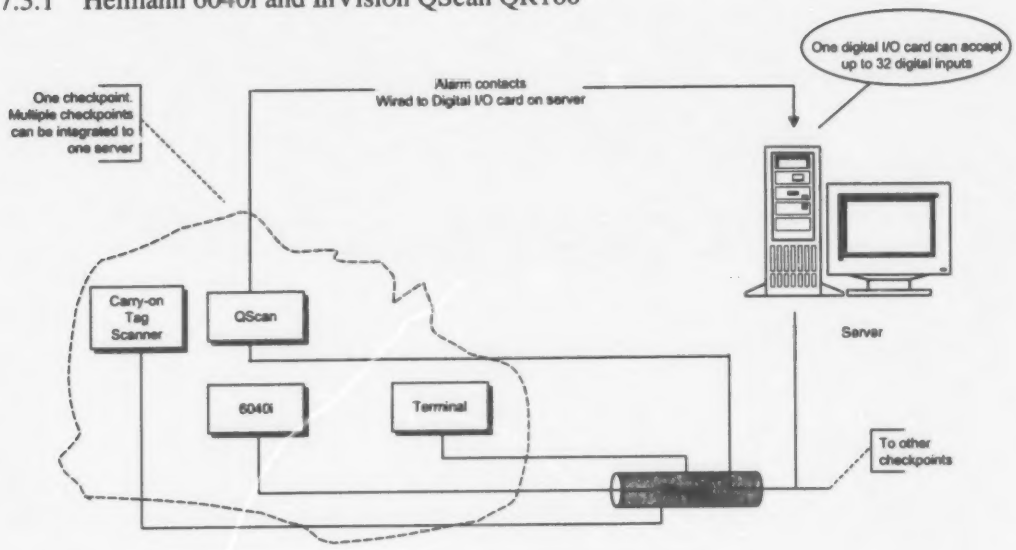

One digital I/O card can accept up to 32 digital inputs
Alarm contacts
Wired to Digital I/O card on server
One checkpoint. Multiple checkpoints can be integrated to one server
Carry-on Tag Scanner
QScan
Server
6040i
Terminal
To other checkpoints

Figure 23: Heimann 6040i and InVision QScan QR160

- Usage Notes
  - QScan and Heimann are placed in sequence, with the QScan first.
  - Carry-on item tags are scanned at QScan.
  - Results of QScan analysis are displayed on terminal at 6040i with passenger identification and X-ray image data. The terminal replaces the Heimann monitor.
- Integration
  - QScan is connected to server over Ethernet and by alarm contact.
  - On receipt of alarm from QScan, analysis data is accessed by server from internal QScan storage.
  - Custom software on server associates QScan results with bar codes, and communicates with Airline System to establish passenger identification data.
  - Custom software on server associates X-ray image obtained over Ethernet with bar codes and with QScan data.
  - Custom software on server displays passenger identification, X-ray image, and QScan results on a terminal located at Heimann control panel.

- Equipment
  - Heimann 6040i, one per checkpoint (6040a can be upgraded to 6040i).
  - InVision QScan QR160, one per checkpoint.
  - Computer configured as server, one per *n* checkpoints.
  - Terminal, one per checkpoint (may replace 6040i display).
  - Carry-on item bar-code scanners, one per checkpoint.
  - A third scanner would be required if the QScan belt does not feed to the 6040i.
- Enhancements
  - Use RF tag technology instead of bar codes. Passenger data could be stored on RF tag, eliminating need to interface server with airline database.
  - Custom software on server could keep track of passenger flows, false alarm rates, etc.
  - The integration could be accomplished with a simple alarm indicator placed at the existing Heimann display unit. This alarm would indicate the QScan result (pass/fail) while the screener analyzed the X-ray image. The server would coordinate the indication.
- Human Factors / Processing Implications
  - Ensures effective passenger cognitive processing from a passenger requirement perspective.
  - Provides integrated interface to security officer; however, multiple-decision making required for explosives detection and X-ray image review.
  - Results in moderate to high impact on workstation requirements and screener allocation.
  - Requires security officers to make decisions as to how to respond to passenger information
  - May require a significant level of training.

7.3.2 Heimann 6040i and IDS Orion Plus

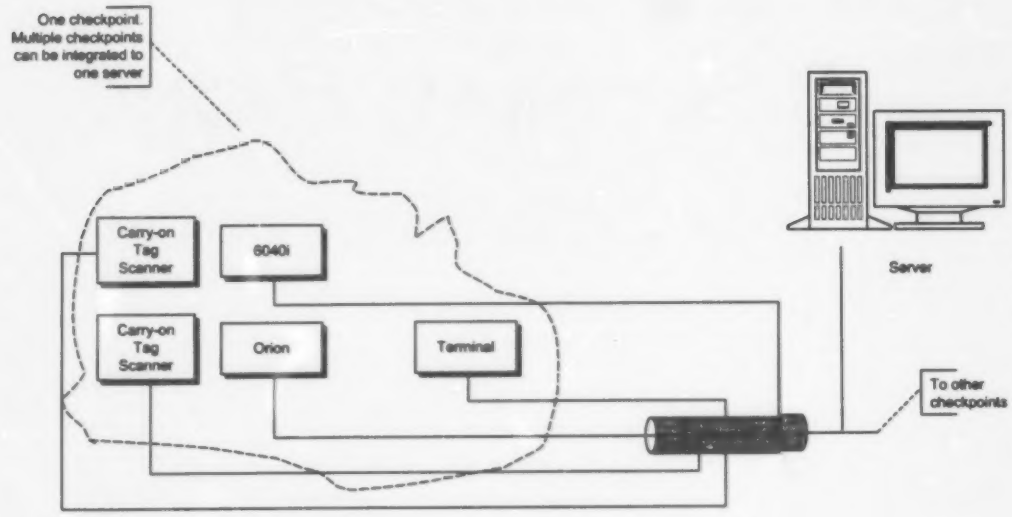


Figure 24: Heimann 6040i and IDS Orion Plus

- Usage Notes
  - Heimann and Orion are placed in sequence, with the Heimann first.
  - Carry-on item tags are scanned at both Heimann and Orion.
  - Heimann scans all carry-on items, Orion scans a subset (possibly one item per passenger).
  - Results of all analysis are displayed on a terminal (X-ray, passenger information, explosives detection).
- Integration
  - Orion is connected to server over Ethernet.
  - Custom software on server associates Orion results with bar codes, and communicates with Airline System to establish passenger identification data.
  - Custom software on server associates X-ray image obtained over Ethernet with bar codes and with Orion data.
  - Custom software on server displays passenger identification, X-ray images and Orion results on a terminal.
- Equipment
  - Heimann 6040i, one per checkpoint (6040a can be upgraded to 6040i).
  - IDS Orion or Orion Plus, one per checkpoint.
  - Computer configured as server, one per *n* checkpoints.
  - Terminal, one per checkpoint.
  - Carry-on item bar-code scanners, two per checkpoint.

- Enhancements
  - Use RF tag technology instead of bar codes. Passenger data could be stored on RF tag, eliminating need to interface server with airline database.
  - Custom software on server could keep track of passenger flows, false alarm rates, etc.
  - Custom software on server could recommend passengers for explosives testing based on profile or on analysis of X-ray images.
  - Orion could be replaced with IDS EVD3000 hand-held unit, which has a faster sampling time and is easier to use. The IDS EVD3000 does not, however, quantify the type of explosives detected.
  - Multiple Orion units per checkpoint could be used to ensure 100% passenger explosive testing.
- Human Factors / Processing Implications
  - Integrated passenger/checked bag information on Orion screen reduces monitoring multiple displays and provides complete information to the security screener.
  - Current processing speed of Orion cannot maintain current throughput levels.
  - Ensures the best usage of technology in scanning random bags or those identified as a threat via X-ray or those belonging to passengers identified as a threat through metal detection or other systems.
  - Will result in modified workstation design and process flow of passengers and baggage.
  - Using hand-held IDS EVD3000 unit, with its faster processing speed, will increase flexibility.
  - Sampling system for Orion will require additional security screener training and testing.
  - Potentially increased error rate when baggage swiped incorrectly
  - Requires security officers to make decisions as to how to respond to passenger information.
  - Will require an additional security officer, as compared to the QScan and 6040i.

7.4 X-Ray/Metal/Explosives Detection Integration Scenario

7.4.1 Heimann 6040i and IDS Orion Plus and CEIA 02PN10

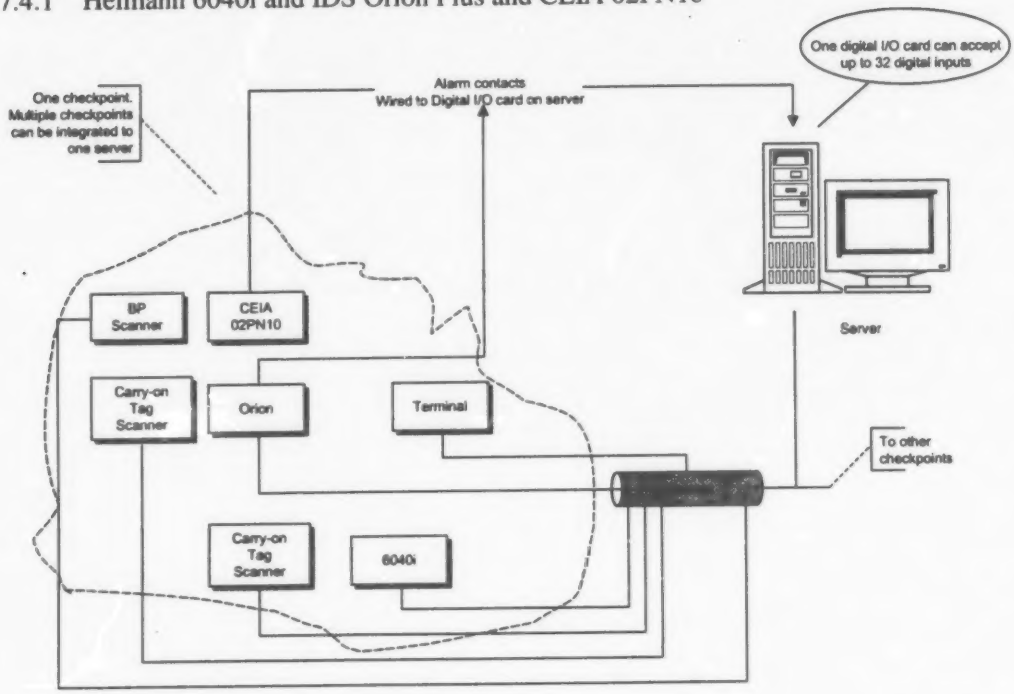


Figure 25: Heimann 6040i and IDS Orion Plus and CEIA 02PN10

- Usage notes
  - Boarding pass is scanned at the CEIA portal.
  - Carry-on item tags are scanned at Orion and at 6040i.
  - Results of Orion analysis and portal scan are displayed on terminal with passenger identification and X-ray image data.

- **See Scenario 7.3.2 for Integration, Equipment, Enhancements and Human Factors / Processing Implications.**

7.4.2 Heimann 6040i and InVision QScan QR160 and CEIA 02PN10

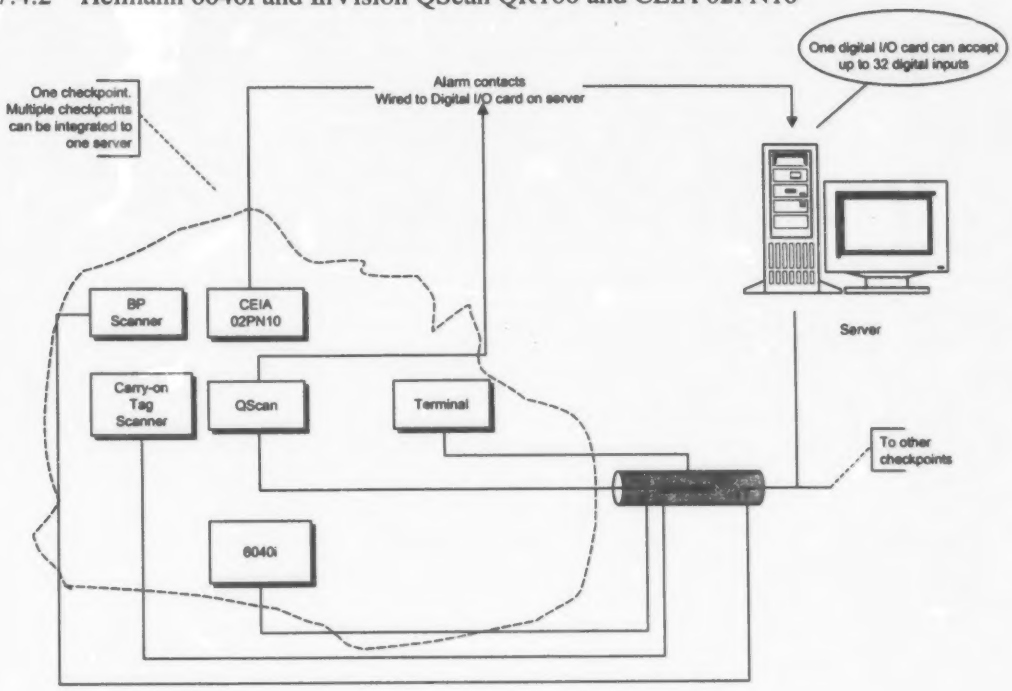

One digital I/O card can accept up to 32 digital inputs
Alarm contacts Wired to Digital I/O card on server
One checkpoint. Multiple checkpoints can be integrated to one server
BP Scanner
CEIA 02PN10
Server
Carry-on Tag Scanner
QScan
Terminal
To other checkpoints
6040i

Figure 26: Heimann 6040i and InVision QScan QR160 and CEIA 02PN10

- Usage notes
  - Boarding pass is scanned at CEIA portal.
  - Carry-on item tags are scanned at X-ray.
  - Passenger identification (for example, name and flight) and results of portal scan and X-ray images are displayed on a terminal at checkpoint.

- **See Scenario 7.3.1 for Integration, Equipment, Enhancements and Human Factors / Processing Implications.**

8 BASE HUMAN FACTORS CONCEPTUAL DESIGN

The integration of various screening technologies will have an impact on the overall workstation and process flow design. In addition, the selection of specific vendors and equipment models will present additional requirements. Therefore, two scenarios have been selected to suggest general design principles and requirements when integrating different types of equipment.

The first scenario presents the integration of the CEIA, QScan and Heimann 6040i. The assumption is a standardized processing speed of the QScan and Heimann systems that matches the passenger throughput with the CEIA metal detection process. The design also assumes that every piece of carry-on baggage will be processed for explosives detection through the QScan.

The second scenario presents the integration of the CEIA, Orion and Heimann 6040i. This system assumes that the Orion cannot maintain passenger throughput to a satisfactory level. It is therefore assumed that a smaller percentage of baggage will be processed with the Orion system. This may involve the full Orion scanner or the IDS EVD3000 system. Baggage may be randomly selected, or selected based on prior knowledge about the passenger (e.g., passenger information or metal detected) or the baggage (e.g., positive alarm on the X-ray).

Figure 27 suggests a layout for one screening point of the CEIA, QScan and Heimann 6040i while Figure 28 provides a suggested layout for two screening points of this integration system. Features of this design include:

- Signage at the beginning of the queue to instruct passengers of requirements prior to entering the security screening process (e.g., document presentation, divestment of metal objects, removal of jacket). Use icons or minimal text (e.g., international symbols) and situate signage in clear view and at standing eye level (50th percentile female Caucasian should accommodate the range of user populations).

- A preparation table within the queue line to allow passengers to prepare themselves and their baggage for screening. Baskets or bins for personal items may be provided.

- A security screener at the entrance to each individual system to assist passengers by placing items on conveyor, reviewing boarding cards and directing passengers through the CEIA portal at the appropriate time.

- Visual signals at the front of the CEIA portal to indicate passage through the portal (i.e., stop/go lights). This will assist in directing the queue to proceed efficiently through the process.

- Two CEIA portals to increase passenger throughput. If the CEIA detects metal on the passenger, rather than stepping back through the portal and re-entering the secure area as is currently done, the passenger will be directed to a secondary portal off to the side for secondary screening by an additional security screener. This will improve throughput as additional passengers can be processed through the primary CEIA portal. During low volume periods, the original process using only one portal can be maintained to eliminate the need for a secondary security screener.

- Bar-code scanner/RF tag reader, QScan and Heimann 6040i systems integrated into one fluid system. The processing speeds are synchronized.

- Visual alarm from the QScan attached to Heimann 6040i monitor. If the baggage passes QScan processing, a green LED is lit. Failure is indicated by a red LED. The lights should be well indicated and in the direct line of sight of the screener. The Heimann 6040i monitor displays passenger identification from bar-code or RF tag, results of the CEIA portal scan, and the X-ray images. The screener is able to control the system from this location. An inspection table is provided to allow passengers to gather objects, as well as allow room for baggage inspection. An interview/interrogation room is provided nearby for additional passenger processing, if required.

Figure 29 presents a layout for the CEIA, Heimann 6040i and the Orion system. The Orion system is placed on the inspection table and assumes an additional security screener will be involved in the process. Specific dimensions of the Orion were not available at date of this report. Features of this design are similar to that in the scenario with the QScan equipment. Significant changes include the availability of a hand-held IDS EVD3000 unit rather than the Orion system. During busy periods, this may increase passenger throughput or increase percentages of baggage that may be scanned for explosives.

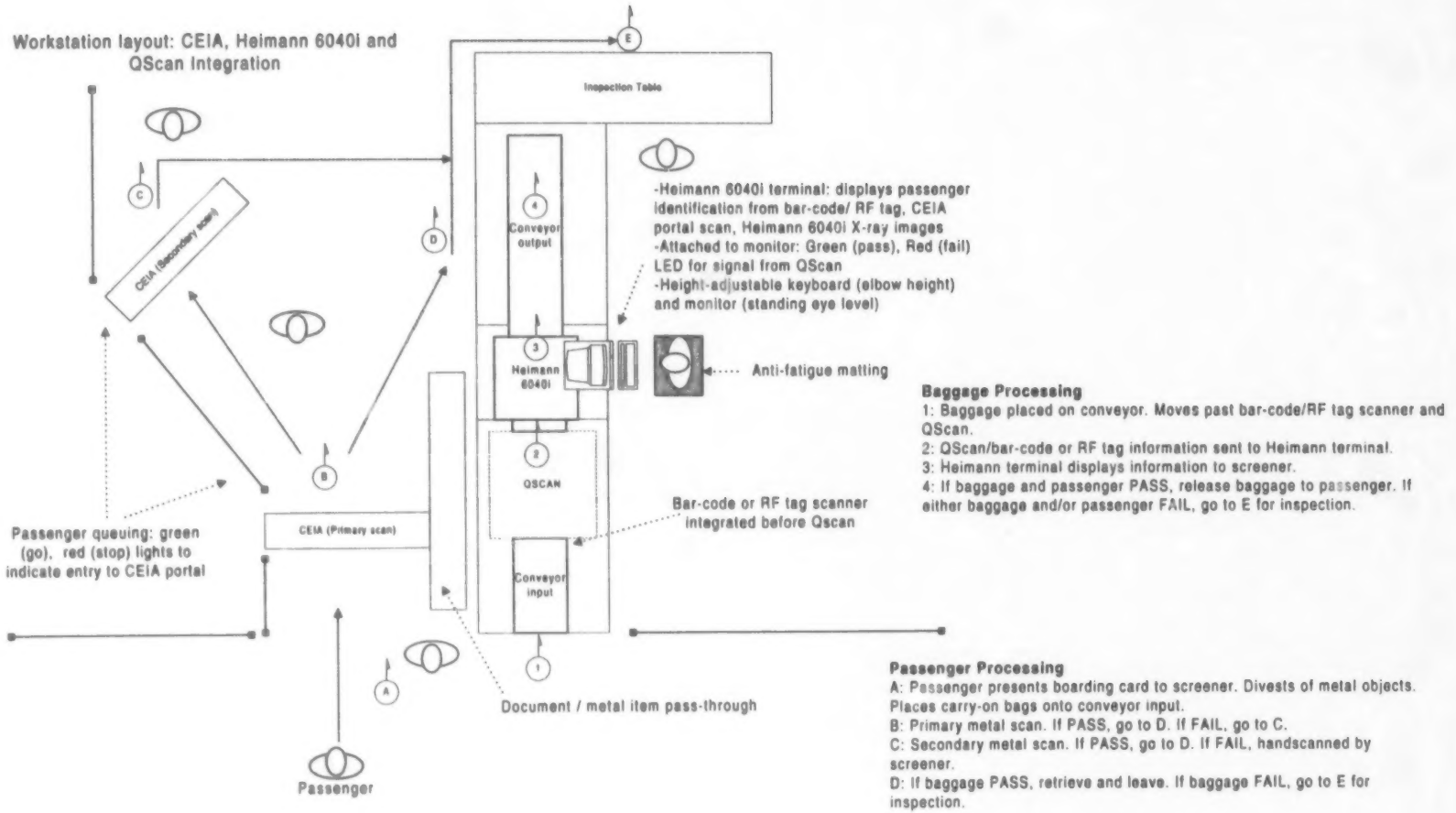

Workstation layout: CEIA, Heimann 6040i and QScan Integration
Inspection Table
E
C
CEIA (Secondary scan)
D
4
Conveyor output
-Heimann 6040i terminal: displays passenger identification from bar-code/ RF tag, CEIA portal scan, Heimann 6040i X-ray images
-Attached to monitor: Green (pass), Red (fail) LED for signal from QScan
-Height-adjustable keyboard (elbow height) and monitor (standing eye level)
3
Heimann 6040i
Anti-fatigue matting
2
QSCAN
Bar-code or RF tag scanner integrated before Qscan
B
CEIA (Primary scan)
Passenger queuing: green (go), red (stop) lights to indicate entry to CEIA portal
Conveyor input
1
A
Document / metal item pass-through
Passenger
Baggage Processing
1: Baggage placed on conveyor. Moves past bar-code/RF tag scanner and QScan.
2: QScan/bar-code or RF tag information sent to Heimann terminal.
3: Heimann terminal displays information to screener.
4: If baggage and passenger PASS, release baggage to passenger. If either baggage and/or passenger FAIL, go to E for inspection.
Passenger Processing
A: Passenger presents boarding card to screener. Divests of metal objects. Places carry-on bags onto conveyor input.
B: Primary metal scan. If PASS, go to D. If FAIL, go to C.
C: Secondary metal scan. If PASS, go to D. If FAIL, handscanned by screener.
D: If baggage PASS, retrieve and leave. If baggage FAIL, go to E for inspection.

Figure 27: Potential individual workstation layout and features for integration of CEIA, Heimann 6040i and QScan

Screening poing layout: CEIA, Heimann 6040i and QScan

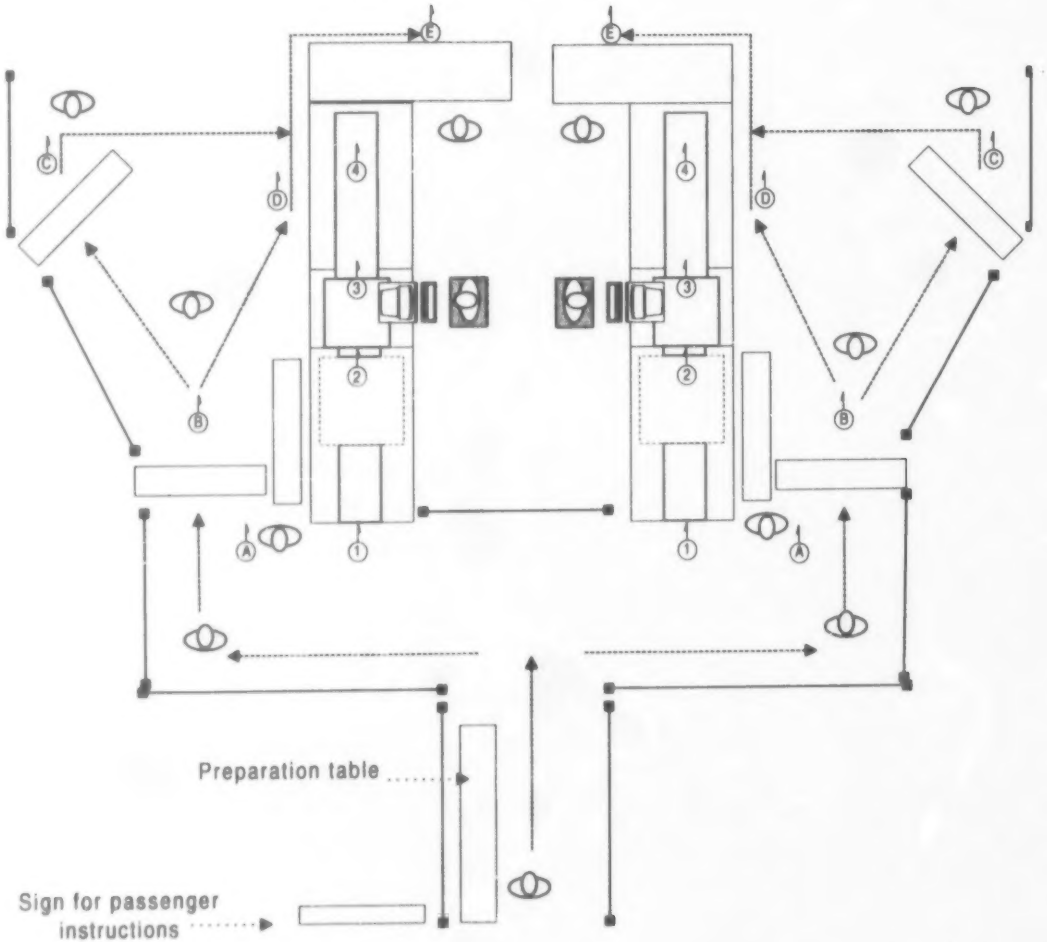


Figure 28: Potential screening point layout and features for integration of CEIA, Heimann 6040i and QScan

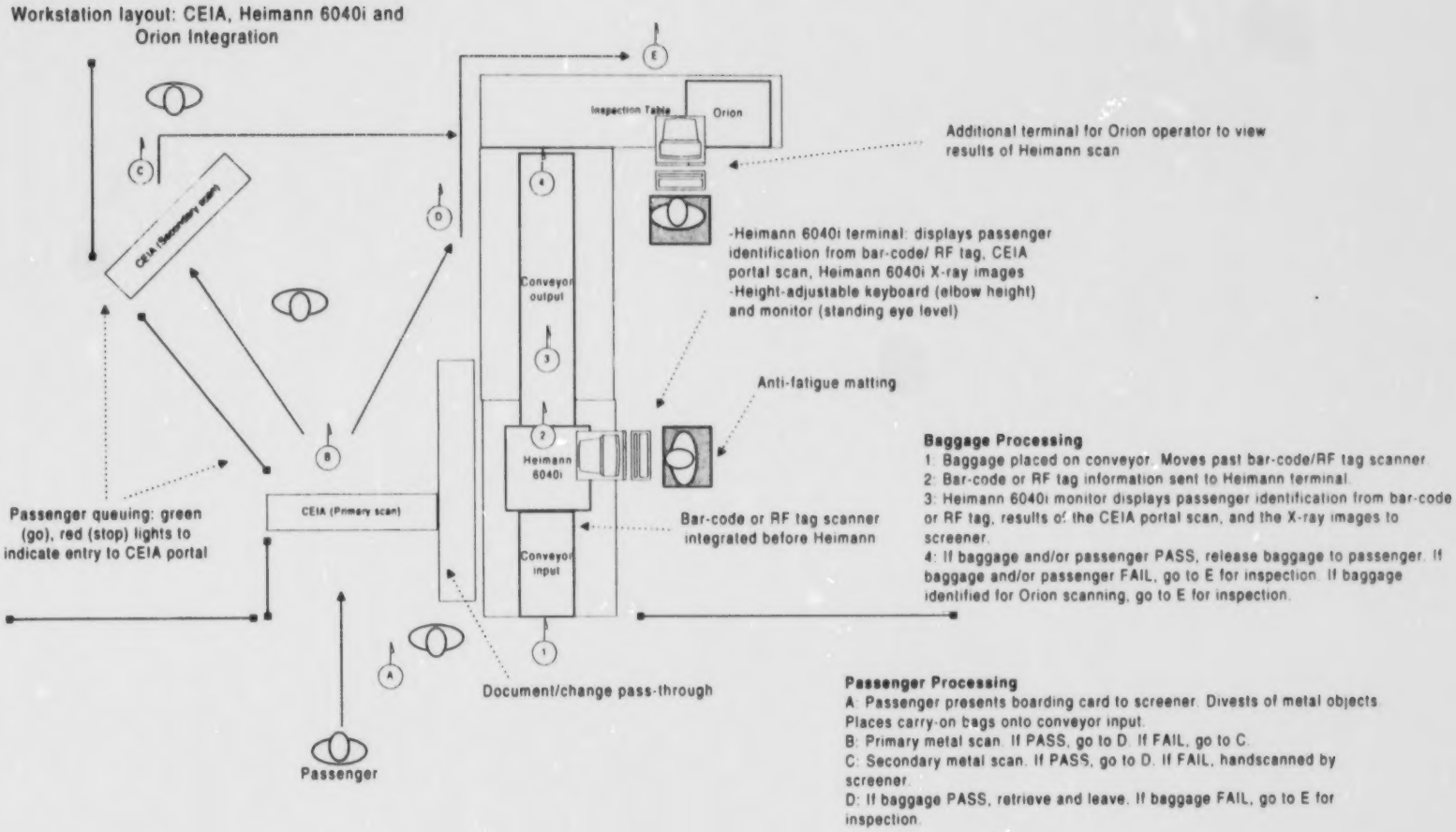

Workstation layout: CEIA, Heimann 6040i and Orion Integration
Inspection Table
Orion
Additional terminal for Orion operator to view results of Heimann scan
-Heimann 6040i terminal: displays passenger identification from bar-code/ RF tag, CEIA portal scan, Heimann 6040i X-ray images
-Height-adjustable keyboard (elbow height) and monitor (standing eye level)
Conveyor output
Anti-fatigue matting
Heimann 6040i
CEIA (Primary scan)
Bar-code or RF tag scanner integrated before Heimann
Conveyor input
Passenger queuing: green (go), red (stop) lights to indicate entry to CEIA portal
Document/change pass-through
Passenger
Baggage Processing
1: Baggage placed on conveyor. Moves past bar-code/RF tag scanner.
2: Bar-code or RF tag information sent to Heimann terminal.
3: Heimann 6040i monitor displays passenger identification from bar-code or RF tag, results of the CEIA portal scan, and the X-ray images to screener.
4: If baggage and/or passenger PASS, release baggage to passenger. If baggage and/or passenger FAIL, go to E for inspection. If baggage identified for Orion scanning, go to E for inspection.
Passenger Processing
A: Passenger presents boarding card to screener. Divests of metal objects. Places carry-on bags onto conveyor input.
B: Primary metal scan. If PASS, go to D. If FAIL, go to C.
C: Secondary metal scan. If PASS, go to D. If FAIL, handscanned by screener.
D: If baggage PASS, retrieve and leave. If baggage FAIL, go to E for inspection.

Figure 29: Potential individual workstation layout and features for integration of CEIA, Heimann 6040i and Orion

Integration of airport security screening equipment presents an opportunity to increase passenger throughput and increase risk detection. A key component of a technological system, however, is the human user. To realize tangible benefits and minimize new problems, the system must be designed with the focus on the human user.

Human Factors Engineering (HFE) examines the entire system design to ensure it meets the capabilities and constraints of the end users of the system. This type of approach optimizes performance, accuracy and efficiency of the human screener and the entire system. End users of the system may include security screening personnel, passengers, security supervisors, airport administration, maintenance crews, and system installers. The two types of user that will interact most often with any integrated security screening system are the security screening personnel and passengers.

The role of the human screener was emphasized throughout all stages of the project, including interviews with airport and security administration, relevant research, and vendor interviews. New technology may be able to detect a potential threat more reliably, automate some portions of the process, and provide the screener with better information; however, overall effectiveness of the system hinges on screener performance. The security screener, through lack of detection, poor decision making, or poor training and skills, can still overrule the threat presented by the equipment.

The U.S. Department of Transportation recommends that screeners be carefully selected, monitored and trained to ensure proficient screening performance. This process includes screener selection test batteries, which are composed of a variety of psychological and cognitive tests, including the ability to detect complex, graphical abstractions such as hidden shapes.

To emphasize the increasing complexity of security screening technology and the requirements of the human user, and to increase threat detection as well as provide a better interface to operators, the U.S. DOT has also requested that the FAA focus on integrating various technologies into a comprehensive security program, rather than on the acquisition and deployment of individual pieces of technology.

Although neither a complete task analysis nor a user profile and requirements document were included in the scope of this project, general recommendations regarding the requirements of the major user categories were developed based on a preliminary investigation of security screening processing, airport security staff interviews, vendor interviews, and examination of documentation of potential candidates for technology integration.

9 EVALUATION OF BASE DESIGNS

The BASE conceptual and human factors designs presented in sections 7 and 8 were evaluated against the same criteria defined and used for the technology integration evaluations in section 5. The evaluations were then analyzed, and a recommendation made on how to proceed with integration.

9.1 Evaluation Against Primary Objectives

Each integration was evaluated against the primary objectives, as shown in Table 13. Note that high scores awarded for integration with explosive detection technology resulted mainly from the introduction of the technology to the screening checkpoint: integration of the technology will thus have only minimal impact on detection.

Table 13: Evaluation of BASE designs against primary objectives

	Improve Flow	Improve Detection	Reduce Errors	Score
CEIA/Orion	L	H	L	5
CEIA/QScan	L	H	L	5
CEIA/6040i	L	L	L	3
QScan/6040i	M	H	H	8
Orion/6040i	L	H	H	7
CEIA/6040i/Orion	L	H	H	7
CEIA/6040i/QScan	M	H	H	8

H = High level of impact (3 points)
M = Moderate level of impact (2 points)
L = Low level of impact (1 point)
NI = No Impact (0 points)

Analysis of the evaluation yielded the following comments:

- CEIA and 6040i integration generated the lowest score, as it was expected to provide only minimal improvements to flow, detection and error rates. In fact, any improvements achieved by this integration could be attributed to the following:
  - Ability to collect statistics on the alarm rate of the metal detection, leading to optimization of threshold settings.
  - Generation of a database of X-ray image scans that can be used to train screeners and aid in the development of automated threat detection systems.

- High improvements in detection are anticipated by any integration that includes the introduction of explosives detection technology. It is expected that introduction of the technology will lead to the generation of false detection alarms; however, a reduction in errors will result from integration as follows:
  - Currently a carry-on bag may be manually searched if an explosive-looking device is observed on the X-ray. An integrated TEDS and X-ray could reduce the frequency of searches.
  - Integration of TEDS units would aid in the determination of optimal threshold levels, thereby reducing false alarms.

- Overall flow would be improved by reducing the frequency of manual searches, or by reducing the frequency of passenger interaction with screeners and equipment. The latter point is particularly relevant to the 6040i and QScan integration.

- Clear signage and bright lighting would also have an impact on throughput, particularly when the airport terminal is crowded.

9.2 Evaluation Against Detailed Criteria

The integration candidates were evaluated against the list of detailed criteria, as shown in Table 14. The purpose of this evaluation was to define the best candidates for integration. The detailed evaluation criteria were divided into three groups: Processing, Human Factors, and Technology. Each candidate was scored in each category, with cumulative scores totalled and compared.

Table 14: Evaluation of BASE designs against detailed criteria

	CEIA / Orion	CEIA / QScan	CEIA / 6040i	QScan/ 6040i	Orion / 6040i	CEIA / 6040i / Orion	CEIA / 6040i / QScan
Processing							
Minimizes degree of change with current technologies	L	M	M	M	M	M	M
Meets operational requirements	M	M	M	H	M	M	M
Optimizes process flow	L	M	M	H	M	L	L
Technology Integration							
Uses off-the-shelf products	H	M	M	M	H	H	M
Presents integrated display to the screener	H	M	M	H	M	M	M
Provides capability for data manipulation	M	L	L	H	H	H	M
Provides practical alternative	H	M	M	H	H	M	M
Provides cost-efficient option	M - $$	M - $$	L - $$$	M - $$	L - $$	M - $$	L - $$$
Doesn't require change in physical space requirements	H	L	H	L	M	M	L
Doesn't require substantial increase in power	H	M	H	M	H	H	M
Human Factors							
Presents effective user interface for screeners	L	M	M	M	L	M	M
Presents effective user interface for passengers	L	M	M	M	L	M	M
Considers screener issues	L	M	M	M	L	L	M
Effectively allocates human/machine function	L	M	M	M	L	M	H
Features effective workstation layout/design	L	M	M	M	L	M	H
Total Score	28	28	30	34	28	31	29

H = High level of impact (3 points)

M = Moderate level of impact (2 points)

L = Low level of impact (1 point)

NI = No Impact (0 points)

9.3 Discussion of BASE Design Evaluations

The 6040i and QScan integration scored highest on the detailed criteria evaluation. This is consistent with its evaluation against primary objectives. It should be noted, however, that the QScan has somewhat limited detection capabilities (it excels at the detection of plastic explosives). Its capabilities require evaluation against detection requirements. It is also important to note that the explosives detection industry is growing; new products are expected within the next one to two years. It is anticipated that at least some of these products could outperform the QScan.

The evaluation yielded very closely matched scores. Because individual scores varied on any one criteria, each integration candidate likely excels at some criteria and performs others less favourably.

Further conclusions resulting from the design work and evaluations are summarized by technology in the following sections.

9.3.1 Integration of Metal Detection Devices

- Screeners would still be required because of the high frequency of alarms that necessitate a physical search or "wanding" of individual passengers. The high alarm rate is caused by the prevalence of such harmless personal items as belt buckles and jewellery.

- Integration would provide the opportunity to gather statistical data on the frequency of alarms and on metal detector measurements. In conjunction with written records kept by screeners (indicating the confiscation of potentially dangerous items), this data could be used to optimize metal detector performance through selection of optimal detection thresholds. Commercial software that provides this capability is available from CEIA for use with the CEIA 02PN10 machines.

- Integration could allow remote control of metal detection devices, permitting modifications to detection thresholds when increased security is required (e.g. when indicated by CAPS). CEIA software provides this capability.

- Integration with explosives detection systems could be used to select certain passengers for secondary screening.

- Integration with a passenger identification system would allow thresholds to be dependent on passenger information, including flight, airline, destination and passenger profiling. CEIA software does not provide this capability, although CEIA expressed a willingness to work with customers to add functionality to its software.

9.3.2 Integration of X-Ray Machines

- Extraction of data from an X-ray machine is complex, and while often theoretically possible, is just as often not practical. Integration of the Heimann 6040a is therefore not recommended.

- Assuming data can be extracted (as with the Heimann 6040i, for example), screeners would still be required to physically search suspect items and to ensure items are properly placed on the X-ray machine conveyor belt. An alternative to physically searching items would be passing them through an integrated EDS system.

- Integration would provide the opportunity to build a database of image data that could be used for training and investigative studies. In particular, a database could be used to aid in the construction of automatic threat detection algorithms.

- Integration with passenger identification systems could be used in conjunction with an expert system to select certain passengers for secondary screening (physical searches, for example).

- Integration with explosives detection systems could be used to select certain passengers for secondary screening (physical searches, for example).

- Integration with passenger identification systems could be used in conjunction with an expert system to select certain passengers for in-depth screening at a central location. For example, all the X-ray images of one passenger's carry-on items could be inspected at a central screening point and, if necessary, the passenger could be apprehended at the boarding gate.

9.3.3 Introduction and Integration of Explosives Detection Devices

- Screeners are required to operate the explosives detection device and physically inspect suspect items and passengers. It should be expected that explosives detection devices will yield a high rate of false alarms because of the number of innocuous items that may cause explosives alarms (for example, some fertilizers and heart medications). Engaging passengers in dialogue before they arrive at the screening portal may reduce these false alarms.

- Integration would provide the opportunity to gather statistical data on the frequency of alarms and on the explosives detector measurements. In conjunction with written records kept by screeners documenting results of secondary screenings, these data could be used to optimize explosives detector performance through selection of optimal detection thresholds.

- Integration could allow remote control of explosives detection devices, permitting modifications to detection thresholds when increased security is required.

- Integration with a passenger identification system could allow thresholds to be dependent on passenger information, including flight, airline, destination and passenger profiling.

9.4 Integration Strategy Recommendation

Based on the data collected during this project, on interviews conducted, and on the design evaluations made and analyzed, the following integration strategy is recommended.

- Visit Atlanta facility and determine effectiveness of its integration scheme.

- Integrate each CEIA 02PN10 metal detector with a central screening facility that uses CEIA-supplied software, for the purpose of gathering statistics. The statistics could then be used to select optimal threshold levels. This integration would also allow equipment sensitivities to be modified unobtrusively.

- Investigate the Heimann 6040i (X-ray) integration capabilities more fully and integrate each unit with a central screening facility for the primary purpose of data gathering and training. This integration would also enable images to be analyzed at the same time as the front-line screener performs the analysis. In parallel with integration steps outlined below, investigation can then begin in earnest into the use of expert system object recognition algorithms.

- Select a method of passenger and carry-on item identification (bar code, RF tag), and implement. Depending on decision, this may include integration with airline passenger systems.

- Integrate CEIA software with X-ray image data and with identification information. Present passenger identification information to front-line screeners.

- Select an explosives detection technology and integrate with existing equipment. Develop and implement a single user interface at each screening point showing explosives detection results, X-ray images and passenger information.

10 EXPANDED INTEGRATION CANDIDATES

As more people travel through airports, the process of handling the people on the ground becomes a key area of focus. At one time it was thought that expediting travel could only be achieved at the cost of a loss of security. With the introduction of new technologies, however, travel can be expedited while actually enhancing security. The travel document is the key. Standards for paper travel documents have been in existence for many years. Standards for electronic travel documents are just emerging.

The new standards take into account the issues of travel document review and format, language, truncation and naming conventions, and introduction of new technologies. New travel documents would likely employ some form of biometric information such as finger or hand geometry. A simple approach would be to simply include a biometric chip into a passport. This would provide more assurance that the travel document belongs to the bearer. More sophisticated approaches could involve a multipurpose smart card with biometric capability to take the place of a passport, driver's license, birth certificate and other civil registry functions.

Use of a biometric-enabled document or card resolves the question, "Is this person the same as the one described on the document?" Ultimately, the cards would be dispensed with as biometric information is checked against a database. The question then becomes "Who is this person?"

There are significant issues to be resolved in order to move forward:

- **Technical issues**. There are numerous technical challenges, not the least of which is ensuring that a consistent set of standards is adopted. A good set of broadly accepted standards is absolutely vital.

- **Transition issues**. It will take considerable time for existing documents to be replaced, necessitating a coexistence strategy.

- **Impact on security**. A key consideration will be the impact on the deployment of existing airport security-related equipment. A deep understanding of these technologies is required to fully evaluate the impact on security.

- **Privacy issues**. Use of advanced identification technologies such as biometrics for identification, especially if it involves a central database, will create a fear of "big brother." This will need to be handled carefully.

- **Cost vs. risk to public safety**. An important consideration in evaluating the potential for the use of advanced technologies is the balance between the cost of deploying the technology and the incremental improvement in public safety.

- **Commercial issues**. How governments and private companies will be involved and recover costs are two key issues. The involvement of private companies is a particularly sensitive issue given the privacy concerns.

An understanding of recent technological advances is essential in determining the direction of the airline industry as it moves toward the integration of airport security equipment. Key areas of existing and future technologies include the following:

- **Security equipment for screening passengers**

  At present, more than 25 companies throughout the world research, develop and market security equipment and instruments that screen passengers and their baggage using a variety of fundamental scientific processes and equipment configurations. These include systems that utilize ion vapour characterization, neutron stream analysis, nuclear magnetic resonance, thermal neutron activation and vapour trace analysis in several configurations.

- **Card technologies**

  Card technologies are becoming a standard medium in both the public and private sector for storing and processing information. These technologies are having a dramatic impact on the manner in which people acquire goods and services. The major types of card technologies currently in use include magnetic strip cards, integrated circuit or Smart Cards, and optical storage cards.

- **Advanced identification and biometrics technology**

  The use of advanced identification techniques, such as biometrics technology, will enable governments and businesses to improve their ability to identify passengers. Biometrics technology is becoming a generally accepted method of providing a high degree of certainty that each person in a database system has only one identity, or alternatively, identifying an unknown person. Biometrics can provide both integrity and speed to government verification systems, and facilitate the rapid movement of passengers through inspection processes in airports. Such systems could also be used for commercial transactions to decrease fraud and increase security.

  Biometrics technologies currently in use or ready for market release include automatic identification via fingerprints, hand geometry, facial-thermal imaging, voice recognition and retinal scans. The technology is modular and can be changed easily over time by simply plugging in replacements for identification components.

  Table 15 presents a list of technologies that could be developed (EXPANDED technology candidates) and their principal advantages.

Table 15: EXPANDED technology candidates

Technology	Advantages
EDS hand-held wand	▪ The IDS EVD 3000 is an existing product. ▪ Sampling and analysis times are superior to the IDS Orion / Barringer Ionscan type detectors (about 20 seconds total). ▪ Sampling is relatively easy: integrated with explosive vapour sensors and existing metal detectors. ▪ Integration is via a serial interface; therefore, it is probable that data exchange is not straightforward.
Boarding pass scanner	▪ Could appear on market in the next year or two. ▪ Easy to use. ▪ Analysis times expected to be between 30 and 60 seconds.
EDS laser detector	▪ In development stages. ▪ Easy to use: presence of device may not be at all apparent to passengers; physically integrated with X-ray machine.
EDS walkthrough portal	▪ IDS NOVA Walkthrough expected to be market ready in first quarter of 2001. ▪ Inherently flexible and expandable (features metal, narcotics, radiation and electronic device detection, and video capture). ▪ Easy to use, but may require passengers to pause in the portal. ▪ Sampling and analysis times of less than 30 seconds. ▪ Easily integrated via Ethernet.
Passenger video capture	▪ CCTV surveillance-type systems offer a low-cost method of monitoring activities at many checkpoints from a central location.
Checked baggage X-ray imaging	▪ Could alert passenger checkpoint and boarding gate of need to detain or thoroughly screen passenger. ▪ Could be used to select bags for explosives detection. ▪ Could allow for central checked baggage monitoring station. ▪ Could also be used to track CAPS selectees.
Checked baggage explosives detection	▪ Could alert passenger checkpoint and boarding gate of need to detain or thoroughly screen passenger. ▪ Could allow for a central checked baggage monitoring station.
Passenger profiling system	▪ Could alert screening points of potentially risky passengers.
Baggage handling systems	▪ Could be used to reconcile passenger and checked bag boarding. ▪ Could be used to divert high risk bags (e.g., based on results of passenger or checked baggage screening).
3-D X-ray imaging	▪ Could provide better threat assessment capabilities. ▪ Could be used by computerized object recognition system to automatically detect weapons.
Image analysis systems (pattern recognition)	▪ Could be applied to X-ray image data to automatically analyze images and detect threats.
Biometric analysis	▪ Could be used to uniquely identify passengers, allowing interface with databases of identified high-risk individuals.

10.1 Evaluation of EXPANDED Technology Candidates

The EXPANDED technology candidates were evaluated considering the relative advantages and disadvantages (Table 16), and assessed against the primary objectives (Tables 17 and 18). The candidates were also evaluated to determine their suitability for integration with an integrated passenger and carry-on baggage screening point (Tables 19 and 20). The candidates were divided into two groups: explosives detection devices and other technologies.

Table 16: Evaluation of EXPANDED candidates

Technology	Risk Level	Advantages	Disadvantages	Notes
Video Capture	Low	• Low cost. • Allows remote monitoring of many checkpoints from a central location. • Video can be stored.	• Integration may not be feasible or workable.	• Many systems are commercially available.
Passenger Profiling	Medium	• Provides indication of security risk posed by passenger. • Could be effectively used to select passengers for in-depth screening.	• May be difficult to obtain access to required databases. • May be personal privacy issues.	• CAPS is an example.
Airline Database	High	• Could provide an indication of security risk posed by passenger (based on payment methods, travel itinerary, travel companions).	• Airline systems are unique, requiring custom interfaces. • Airlines may be reluctant to allow access to their databases for competitive reasons.	• Information needed by security could be encoded to RF tag boarding passes at check-in, serving as the link to the information.
Baggage Handling	Low	• Provides location updates of checked baggage. • Allows for automatic diversion of suspect bags. • Most systems are PLC controlled; interface development is straightforward.	• Initial equipment and installation costs of automatic baggage handling systems may be prohibitive.	•
Checked Baggage X-Ray	Medium to High (vendor dependent)	• Image could be analyzed with reference to carry-on item and passenger screening results. • Analysis could be used to divert to TEDS units. • Image could be analyzed with reference to explosive detection results, stored for review. • Images could be used for training purposes. • Images could be used in the development of automatic detection tools.	• Integration capabilities are not clear.	•
Checked Baggage TEDS	Medium to High (vendor dependent)	• Data could be analyzed with reference to carry-on item and passenger screening results. • Results could be used to divert to X-ray machine and/or hand-search station. • Data could be analyzed with reference to X-ray data, stored for re-analysis in the event of a mishap.	• Integration capabilities are not clear.	•
3-D X-Ray	High	• Three-dimensional images would provide data needed to perform automatic threat detection.	• Only one vendor. • High cost. • Integration capabilities not clear.	•
Biometric Analysis	Low	• Provides positive identification of individuals. • Could be used with Passenger Profiling to identify high-risk individuals.	• May be time consuming. • May be personal privacy issues.	•
X-Ray Image Analysis	High	• Provides automatic detection of possible threats.	• Very difficult to develop robust algorithms using two-dimensional X-ray images .	•

The evaluation criteria and process are the same as those used earlier in this report in the assessment of the BASE technology options.

Table 17: Evaluation of EXPANDED candidates against primary objectives

	Improve Flow	Improve Detection	Reduce Error Rates	TOTAL
Video Capture	NI	M	L	3
Passenger Profiling	L	M	M	5
Airline Database	M	NI	NI	2
Baggage Handling	NI	M	L	3
Checked Baggage X-Ray	NI	M	M	4
Checked Baggage TEDS	NI	M	M	4
3-D X-Ray	NI	M	H	5
Biometric Analysis	L	L	L	3
X-Ray Image Analysis	NI	H	H	6

Table 18: Evaluation of explosives detection devices against primary objectives

	Improve Flow	Improve Detection	Reduce Error Rates	TOTAL
Hand-Held Wand	M	M	M	6
Boarding Pass Analyzer	H	H	M	8
Walkthrough System	H	M	H	8
Laser Detection	M	H	M	7

H = High level of impact (3 points)
M = Moderate level of impact (2 points)
L = Low level of impact (1 point)
NI = No Impact (0 points)

Table 19: Evaluation of EXPANDED candidates against detailed criteria

	Video Capture	Passenger Profile	Airline Database	Baggage Handling	Checked Baggage X-Ray	Checked Baggage TEDS	3-D X-Ray (CT Scan)	Biometric Analysis	X-Ray Image Analysis
Processing									
Minimizes degree of change with current technologies	H	L	L	L	L	L	L	L	H
Meets operational requirements	H	M	M	H	M	M	H	M	H
Optimizes process flow	L	L	L	H	M	M	M	L	M
Technology Integration									
Uses off-the-shelf products	M	H	H	H	M	M	M	H	L
Presents integrated display to the screener	H	H	H	M	M	M	M	M	M
Provides capability for data manipulation	M	H	H	M	M	M	H	M	L
Provides practical alternative	M	L	L	M	H	H	M	L	L
Provides cost-efficient option	L	H	H	L	M	M	L	M	L
Human Factors									
Presents effective user interface for screeners	M	M	M	M	M	M	L	M	M
Presents effective user interface for passengers	M	L	H	H	H	H	M	M	H
Considers screener issues	M	L	M	M	M	M	L	M	M
Effectively allocates human/machine function	M	M	M	M	H	H	L	M	M
Total scores	25	23	26	26	26	26	21	22	23

H = High level of compliance with detailed criteria (3 points)

M = Moderate level of compliance with detailed criteria (2 points)

L = Low level of compliance with detailed criteria (1 point)

Table 20: Evaluation of explosives detection devices against detailed criteria

	Hand-Held Wand	Boarding Pass Analyzer	Walkthrough System	Laser Detection
Processing				
Minimizes degree of change with current technologies	M	M	H	M
Meets operational requirements	M	M	H	M
Optimizes process flow	M	M	H	M
Technology Integration				
Uses off-the-shelf products	M	L	L	L
Presents integrated display to the screener	L	M	H	H
Provides capability for data manipulation	L	L	M	M
Provides practical alternative	M	M	M	M
Provides cost-efficient option	H	M	M	M
Human Factors				
Presents effective user interface for screeners	M	H	H	H
Presents effective user interface for passengers	M	M	M	H
Considers screener issues	M	M	M	M
Effectively allocates human/machine function	M	M	H	H
Total scores	23	23	29	27

H = High level of compliance with detailed criteria (3 points)

M = Moderate level of compliance with detailed criteria (2 points)

L = Low level of compliance with detailed criteria (1 point)

10.2 Discussion of EXPANDED Evaluations

All EXPANDED technologies yielded about the same evaluation score. This is significant in that it indicates that all candidates could be expected to contribute to improved airport security in an integrated environment. The similar scores are probably also indicative, in some cases, of the lack of information available about the capabilities of many of the EXPANDED candidates.

Individual EXPANDED candidates are discussed in detail in section 11.

11 INNOVATIONS

There are a number of technologies and process improvements that have the potential to accomplish any one or combination of the following goals: improve flow; increase detection; and reduce false positives. Some innovations are currently in use outside of the airport environment, but may be well-suited for implementation as part of the security process. In an effort to present "possible technologies", we have not applied as rigid criteria as in previous sections of this report, and have taken the liberty of being creative in our selection.

11.1 Passenger Screening Technology

11.1.1 NOVA Walkthrough

A passenger walks through the portal opening, pausing in the portal for a few seconds. An alarm is generated if the level of metal or explosives detected exceeds preset thresholds. This is an example of two technologies – metal and explosives detection – seamlessly integrated into one unit. While production is tentatively set for the first quarter of 2001, it is unclear if this unit will actually be produced. This portal has the ability to integrate by Ethernet or by alarm contacts, adding to its flexibility of application.

11.1.2 QControl System (ADT)

The QControl system is designed to process travellers quickly and safely through a screening checkpoint by providing them with automated directions before they reach the entrance. Passengers are given instructions as to what to do with their baggage and how to pass through the screening area once inside.

The proper screening of travellers entering and exiting an airport is absolutely critical in maintaining security. The inbound system provides automated directional information, while the outbound system combines three unique technologies (Directional Doppler Microwave, Optical Detectors and Video Surveillance) to make any airport screening process more accurate and efficient. When used together, these system may dramatically lower security costs by allowing for reduced inbound personnel and unmanned outbound screening areas. The QControl system is currently being used at Miami International Airport.

Figure 30: QControl system (ADT)

11.2 Video Capture

Video capture can be used at a number of points within the security process, and can be purchased as an option with the NOVA Walkthrough unit. There are minimum screener requirements, apart from collecting the printed image. Inconvenience to passengers is also limited to simply entering and exiting the portal area.

11.3 Advanced Identification and Biometrics Technology

The use of advanced identification techniques, such as biometrics technology, will enable governments and businesses to improve their ability to identify passengers. Biometrics technology is becoming a generally accepted method of providing a high degree of certainty that each person in a database system has only one identity, or alternatively, identifying an unknown person. Biometrics can provide both integrity and speed to government verification systems, and facilitate the rapid movement of passengers through inspection processes in airports. Such systems could also be used for commercial transactions to decrease fraud and increase security.

Biometrics technologies currently in use or ready for market release include automatic identification via fingerprints, hand geometry, facial-thermal imaging, voice recognition and retinal scans. The technology is modular and can be changed easily over time by simply plugging in replacements for identification components.

11.3.1 Facial Recognition Software

The ID-2000 Image Detection and Facial Recognition Software (Imagis Technologies Inc.) system captures a facial image, typically via video or digital camera. A large number of facial features around the central part of the face are identified, then encoded using advanced algorithms. Using mathematical transformations, a biometric code is created which can be compared to other encoded images in a database. Text records containing relevant information regarding the individual can also be included with the image. Intuitive and easily linked to other databases at other locations, ID-2000 is a highly effective technology for identifying people. (source: Imagis literature)

As passengers queue for primary inspection, typically at a metal detection portal, their faces could be digitally photographed, relaying the image to a PC loaded with facial recognition software. The image could then be compared to a database of known terrorists, criminals, or other identified group. The availability of current data is critical, as is the data source. In addition, the technology and process must be in place to access either real-time, or near-time data. There would be no reduction in process flow, as passengers would only need to direct their attention to a single focal point, such as a green light signaling them to advance to the portal entrance.

11.3.2 Iris Recognition Technology

The iris recognition process (IriScan Inc.) begins with video-based image acquisition that locates the eye and iris. The boundaries of the pupil and limbus are defined, eyelid occlusion and specular reflection are discounted, and quality of image is determined for

processing. The iris pattern is processed and encoded into an IrisCode™ record, which is stored and used for recognition in any transaction when a live iris is presented for comparison. Eyeglasses and contact lenses are accommodated easily. Identification time averages about two seconds.

While this technology offers accurate matching between a person's iris and a database record, there are process implications within an airport security environment. One of the key drawbacks is the time it takes to approach a unit, have one's iris scanned, and exit the area to continue with the regular security process. Possible placement of the IriScan unit could be at the check-in station, before passengers receive a boarding pass. If we work on the premise that passengers travelling with paper tickets are a higher risk group than those travelling with electronic tickets, scanning at this point is the most plausible. Because processing time at the check-in station is typically higher than at other points in the check-in process, biometric identification would perhaps have the least impact on passengers at this point.

11.4 Queue Management

After having observed airports throughout Canada and the United States, it is readily apparent that there is no standard layout for queues within the security process. Given the different special and operational constraints, as well as the varying layout of each airport, it is difficult to suggest an ideal layout without having to adjust for each case. It is possible however, to list the attributes of an effective layout, which can be applied to the vast majority of airports.

- **Flexible**. Above any other consideration, a queue must be able to accommodate peak volumes, as well as times when traffic is light. Moveable "snaking queues" are ideal for this reason, as they can be moved on the floor to accommodate changes in volume. This tool is used widely in banks and government institutions to manage often lengthy queues.

- **Expediter**. This individual is stationed at a queue when volumes increase, ensuring that passengers are in the correct area and have all the necessary documentation (boarding card, identification, etc.). In the pre-metal detection screening queue, for instance, the individual may emphasize the need to remove all metal objects from pockets and jackets. This does not have to be a specific staff member. A security screening staff member can be designated to fulfill the expediter role at times of peak volume. The airlines may designate such an individual to monitor check-in queues at similar times. We observed an expediter at the check-in queue at Toronto's Pearson International Airport, where passengers were routinely redirected to the correct area. This saves precious time for the passengers as well as airline and security staff.

11.5 Signage

Signage within most airports is generally standard, using international symbols for amenities such as taxis and restrooms. Systems such as the HESS systems, with a clear visual indicator for "stop" or "go" are not as commonly used. Again, banks often use these types of electronic signs to direct their customers to an available station. Similarly, a sign could advise a passenger to proceed to a particular portal. For instance, passengers may be directed to a second portal for a (random) physical bag search, as designated by the supervisor. Additionally, a sign is a non-personal method of directing "interesting" (from a security standpoint) individuals to a secondary area.

11.6 Spacing

We observed that the most effective screening process occurred where there was adequate space for passengers and security staff. A case where space was a limiting factor was at Seattle-Tacoma Airport. While the building offered enough space to expand the portal area substantially, screening operations were artificially restricted to a very small area, where passengers often triggered the primary metal detector, only to be left unchallenged by screening officers. What we observed was not a case of inadequate staff levels, but simply operations compressed into an unworkable amount of space.

11.7 Passenger Profiling

A chief byproduct of security equipment integration would be a robust passenger profile. If every bit of relevant information were collected on a passenger's trip (e.g., amount of trace explosives detected, metal detection results, positive X-ray scans, etc.), security agencies and airlines could have a more complete picture of the profile of its existing and potential passengers.

Passenger profiles can include several components:

- Biometric Information (e.g., facial image, fingerprints, iris image).
- Security Authority Information (FBI/CSIS profiles, criminal records).
- Airline Information (linked to frequent flier and passenger manifest data).

There are issues with passenger profiling, such as its potentially discriminatory uses, the privacy it may invade and the potential for data to be accessed by unauthorized parties. As with any database, however, data security should be the highest possible, and use of passenger information must be in accordance with the aim of reducing risk to all passengers and related parties. Notwithstanding these caveats, there is a strong case to be made for expanding passenger profiling.

It is widely understood that the major obstacle to developing a comprehensive air passenger database is the lack of commitment by the airlines themselves. Passenger data is an extremely precious commodity and the reluctance to share it is understandable. A

pseudo-integration could be accomplished by writing a subset of airline database information on a passenger's RF boarding pass at check-in. The key driver to encourage cooperation is the benefit the airlines could derive from pursuing this initiative, which is not currently thought to be sufficiently valuable.

11.8 Tag Technologies

Card technologies are becoming a standard medium in both the public and private sector for storing and processing information. These technologies are having a dramatic impact on the manner in which people acquire goods and services. The major types of card technologies currently in use include magnetic strip cards, integrated circuit or Smart Cards, and optical storage cards.

11.8.1 Texas Instruments' Tag-it Technology

Tag-it "smart labels" are paper-thin, flexible, printable and capable of being read simultaneously by reader units installed within baggage conveyors or by hand-held units. The Tag-it system can be integrated with existing baggage tags and used in the form of ATBs or tickets for faster and easier processing of passengers through airport check-in and baggage claim areas. For the airline industry, getting passengers to their destinations on time and with their accompanying luggage is a feat that requires identifying and tracking millions of items daily.

As the airline industry implements an international Positive Passenger Baggage Matching (PPBM) system, Tag-it smart labels provide reliable, unique identification that automatically matches passengers to their bags during flight boarding for faster and more accurate baggage handling. Other benefits include eliminating the expense of having to reload an aircraft because an item is on the wrong plane, or compensating passengers for misrouted luggage. A positive passenger-to-baggage match also ensures a higher level of overall airport and airline security.

The new TIRIS Tag-it transponders feature read/write capabilities, allowing stored information to be updated "on-the-fly," and powerful simultaneous identification (SID) so that multiple tagged items may be accurately identified at the same time as they pass a reading location. With TIRIS Tag-it, parcels or bags overlapped on a conveyor do not have to be physically separated and read individually. This technology has several additional advantages for baggage handling and electronic ticketing applications, including the ability to fit seamlessly into existing departure control (DCS) baggage reconciliation systems (BRS), and co-reside with bar-code printing and scanning systems; provide extended data storage capability without increasing the size of the label; carry within the tag key elements of the baggage source message (BSM), so that there is no need to reference a database to handle and route baggage; be delivered through existing bag tag printer suppliers without occupying additional space at the check-in desk; and be delivered at a volume price, which makes RF bag tags cost-effective as a consumable label.

11.9 Card Technology

11.9.1 LaserCard Optical Memory Card

A LaserCard is a credit card-sized optical memory card that has 4.1 megabytes of non-erasable digital storage. This card can contain a large amount of passenger information, including trips taken, contact information, a holographic image of the passenger, and a host of biometric information. In conjunction with law enforcement agencies and airlines, the optical memory card may have positive applications within the airport security environment.

11.10 Internet and Electronic Commerce

Electronic commerce, the buying and selling of goods and services electronically, is rapidly becoming a viable method of collecting business information and conducting business transactions. The Internet has become the dominant electronic marketplace for conducting business around the globe.

Existing and future technologies will allow passengers to access a broad range of services, ranging from checking flight arrivals and departures to booking hotel rooms and automobiles. The Internet will facilitate access to these services. Recent advances in Internet-related technologies will also enable easier and more cost-effective information exchange between separate systems managed by different stakeholders.

12 PRINCIPAL OBSERVATIONS AND CONCLUSIONS

In evaluating security equipment integration candidates, three overall objectives were considered: increase process flow, improve detection and decrease the number of false positives. Candidates were also assessed in terms of their implications with regard to people (human factors), process (e.g., passenger and baggage technology), and technology. The results of this evaluation are listed below.

12.1 People (Human Factors)

- **Integration is not expected to reduce the number of personnel** required at security checkpoints because:
  - high alarm rates necessitate the frequent physical inspection and manual screening of passengers and carry-on items;
  - effective X-ray equipment use requires that bags be spaced apart and positioned to maximize image size and eliminate jamming;
  - sufficient personnel are needed to ensure that suspect passengers can be quickly apprehended with minimal distruption to the continued processing of following passengers;
  - despite clear signage at primary inspection points, passengers routinely neglect to remove metal objects from their clothes, purses, bags, etc., requiring security officer intervention.

- **Screeners would be required to operate integrated explosive detection devices** and to physically inspect suspect items and passengers. It is expected that explosives detection devices will yield a high rate of false alarms because of the number of innocuous items that may cause alarms (for example, some heart medications).

- **Security officer training needs to be consistent and thorough**. Many stakeholders interviewed believe that this is a substantial area of risk. During airport inspections, instances were observed where screeners were distracted and unsure of how to proceed while processing high passenger volumes. Insufficient training and lower wages were cited as contributors, but layout, staffing levels and equipment utilization were also issues.

12.2 Process (Passenger and Baggage Screening)

- **Integration with passenger identification systems** could be used in conjunction with an expert system to select certain passengers for in-depth screening at a central location. For example, all the X-ray images of passengers' carry-on and checked baggage could be inspected at a central screening point and, if necessary, the passenger could be apprehended at the boarding gate (e.g., Computer-Assisted Passenger Screening).

- **Integration would provide the opportunity to gather statistical data on the frequency of alarms and on explosive detector measurements**. Along with

written records kept by screeners documenting the results of secondary screenings, this data could be used to optimize explosive detector performance through selection of an optimal detection threshold. This could also be applied to metal detection.

- **Manual inspection of X-ray images of checked bags, combined with passenger information** (obtained from bar-code/RF tag on bag), could be used to further divert checked bags for manual inspection. By integrating the checked baggage system with the passenger security checkpoint and departure gate, screeners at those locations could be alerted, thus streamlining the process of apprehending passengers.

- **Incorporating queue management staff would increase throughput significantly**. It was observed that the number of passengers entering incorrect screening areas or check-in counters was noticeably reduced when staff members were available to help passengers in the queues. Assistance was as simple as confirming a passenger's destination and documentation.

- **Not all individuals passing through security are passengers**. At most airports in the U.S., members of the public are allowed to pass through security. "Meeters and greeters" are not subject to boarding pass checks, as are passengers. Only metal detection and X-ray and/or manual search of any hand-held baggage are required for individuals who are not passengers.

12.3 Technology (Integration)

- **Integration of detection systems with a passenger identification system** could enable a complete profile of each passenger to be logged and archived, for any of a range of profiling initiatives. The passenger identification system could contain information such as flight number, airline and destination.

- **To be useful, integration would need to include identification capabilities for both passengers and objects**. Two options were identified:
  - Boarding passes and all items could be tagged with bar codes at check-in. At security checkpoints, bar codes would be scanned and airline systems queried to establish passenger information (for example, name, flight number, departure gate, departure time, destination).
  - Boarding passes and all items could be tagged with radio frequency tags at check-in. The RF tags would be used in the same way as bar codes, or the RF tags could be encoded with pertinent passenger information (for example, name, flight number, departure gate, departure time, destination). In the latter case, interfacing with airline systems would not be needed. Because RF tags have read/write capability, the tags could be updated automatically at each security checkpoint to include security check results. At the departure gate, a final reading of each tag would confirm that the passenger/carry-on item had passed all security checkpoints.

- **Trace vapour detection technology is adequate**. Laboratory trials have demonstrated that trace vapour detection is about 70 percent effective and can detect explosives residue on the hands of a bomb maker or accomplice. While this percentage is not particularly impressive on its own, this technology does add to the overall detection process.

- **Integration could allow remote metal and explosives detection monitoring,** permitting modifications to detection thresholds to be made when increased security is required.

- **Integration of an X-ray system with other equipment types, while theoretically possible, would not often be practical**. Extraction of data from an X-ray unit would be an extremely complex project, which makes the Heimann 6040a a poor integration candidate.

- **Integration of X-ray systems would provide the opportunity to build a database of images**, which could be used for training and investigative studies. A database could also aid in the construction of automatic threat detection algorithms, which could be used to highlight suspicious objects. The following caveats, however, would apply:
  - **Image data from the Heimann 6040i may not be sufficient** to develop robust object detection algorithms. As a result, algorithms may yield unacceptably high levels of "nuisance" alarms by highlighting objects which, to the eye, are obviously not dangerous;
  - **Image data with three-dimensional information could be more usefully analyzed** than the two-dimensional data provided by Heimann-type equipment. Ideally, any object recognition program would provide immediate feedback to screeners. Integration of individual X-ray units with object recognition hardware and software might best be performed at the X-ray location.

13 OVERALL RECOMMENDATIONS

Integration would best be enabled in two stages. Stage one would involve looking at current pilot projects and investigating the most favourable integration candidates. Stage two would involve integrating innovative types of equipment, including types that are currently available and those still in development.

13.1 Stage One Integration

- Assess the effectiveness of Atlanta Airport's integration initiative. Initiatives at this location were unable to be adequately explored within the conduct of this project.
- Determine the usefulness of video capture technology already in use at Sea-Tac and Miami International Airport.
- Select a method of passenger and carry-on item identification (bar code, RF tag), and implement. Depending on the technology chosen, this may require integration with airline passenger systems.

13.2 Stage Two Integration

- Investigate passenger profiling systems, including the use of third party (RCMP, FBI) database information and biometrics.
- Integrate each CEIA 02PN10 metal detector with a central screening facility that uses CEIA-supplied software, for the purpose of gathering statistics. The statistics could then be used to select optimal threshold levels. This integration would also allow equipment sensitivities to be modified unobtrusively.
- Investigate the Heimann 6040i (X-ray) integration capabilities more fully and integrate each unit with a central screening facility for the primary purpose of data gathering and training. This integration would also enable images to be analyzed at the same time as the front-line screener performs the analysis. In parallel with integration steps outlined below, investigation can then begin in earnest into the use of expert system object recognition algorithms.
- Select a method of passenger and carry-on item identification (bar code, RF tag), and implement. Depending on the technology chosen, this may require integration with airline passenger systems.
- Integrate CEIA software with X-ray image data and with identification information. Present passenger identification information to front-line screeners.
- Select an explosives detection technology and integrate with existing equipment. Develop and implement a single user interface at each screening point showing explosives detection results, X-ray images and passenger information.
- Integrate checked baggage systems with passenger screening and information systems.

14 PROJECT FOLLOW-UP

The following are areas in which further research is or may be required to obtain a better understanding of the implications of technological advancement on airport/airline operations, and to determine the best alternatives for their use. In addition, initiatives that could assist in overall facility planning are indicated.

- **Development of screening line standards, layouts and configurations** – Miami International Airport is in the process of defining specific standards that will include all environmental and design issues. Further examination of this critical initiative and any others currently underway to optimize process flow would be beneficial.

- **Alternatives and their effectiveness** – Some countries have opted for other approaches to explosives detection, such as dual-scan X-rays, trace detection portals, or newer developments. The benefits and costs of these alternatives should be investigated.

- **Threat Risk Impact Assessment (TRIA)** – This process adds "Impact" to an analysis of threats/risks, and presents strategies to respond to risk levels. Many of the stakeholders contacted during the course of this project were not convinced that integration costs could be justified, given the range of other initiatives that could be pursued. One concern was that security would only be marginally improved, if at all, through the integration of security equipment. A TRIA would evaluate the impacts associated with particular risk levels, which would then drive initiatives aimed at mitigating the implications and risks.

- **Definition of the benefits of data integration** – Vendors will need to be motivated to incur the costs required to develop security equipment that is more amenable to data integration. Most vendors indicated that clear regulatory standards/support/mandates would be required to provide direction to the industry in order to achieve integration. These regulatory bodies would also need to clearly define the expected benefits of data integration in terms of detection rates, false alarms and passenger throughput rates.

Appendix A: Vendor Survey Package

The attached package was e-mailed to each identified airport security equipment vendor:

December 7, 1999

Dear Vendor Representative:

Potential System Integration of Existing Airport Security Equipment Study

On behalf of the Transportation Development Center (TDC), KPMG Consulting LP, hereafter referred to as KPMG, is conducting an investigative study into the potential system integration of existing airport security equipment. The information gathered in this project supplements any information collected for a recent study conducted by Telexis Corporation, also on behalf of TDC.

In order for KPMG to determine integration issues related to airport security, we require general market information and market trends as well as detailed information about the equipment your company has installed at airports in Canada and the United States. Detailed information about your equipment will be used for the high-level design portion of our project. As confidentiality is an issue with respect to future plans, we would present the information on a non-attributed basis (i.e., the report would say something like "One or some vendors/manufacturers are doing or thinking of doing the following: ..."). We have attached a Non-Disclosure Agreement (NDA), confirming that any/all technical detail and plans will be communicated only with the TDC.

We would like to collect as much information as possible over the next two (2) weeks. Answers to the questions contained in the attached document may be e-mailed to Adil H. Chagani at KPMG directly, or faxed to his attention at (604) 488-3828. Representatives from KPMG and its partners that will be contacting you with respect to this project include:

Adil H. Chagani, KPMG, 604-691-3117, achagani@kpmg.ca
Ralph K. Herzig, KPMG, 604-691-3245, rherzig@kpmg.ca
Laurel Ritmiller, BC Research, 604-224-4331 ext.633, lritmiller@bcresearch.com
Dan Robinson, BC Research, 604-224-4331 ext.606, drobinson@bcresearch.com
Adrian Lee-Kwen, 905-889-0074, aleekwen@echo-on.net

We will contact you within one (1) week of sending this interview guide to achieve the following:

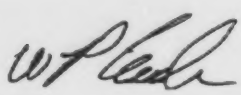
1. Confirm your receipt of this letter and all attachments
2. Address any immediate issues and offer any further information and/or clarification
3. Schedule a mutually acceptable date and time for a follow-up telephone interview. We suggest that this interview will allow both our parties to explore the key issues in more detail.

Please complete the questions in the attached interview guide and return the completed document to us by **Monday, December 20, 1999**. We trust this allows sufficient time for completion, and we will be in contact with you later this week. It is hoped that we can complete the majority of these interviews by the end of December, allowing for vacations and the upcoming holiday season.

If you have any further questions or comments, please feel free to contact:

Adil H. Chagani,
Senior Consultant
KPMG Consulting LP
PO Box 10426, 777 Dunsmuir Street
Vancouver, BC V7X 1K3
Tel: 604-691-3117
Fax: 604-488-3828
E-mail: achagani@kpmg.ca

Yours very truly



W. Paul Levelton
Principal
(604) 691-3409

Enclosures

MUTUAL NON-DISCLOSURE AGREEMENT

ARTICLE 1
PURPOSE

On behalf of the Transportation Development Center, KPMG Consulting LP, hereafter referred to as KPMG, is conducting a project entitled, **"The Conduct of an Investigative Study into the Potential System Integration of Existing Airport Security Equipment."** As part of the information-gathering phase, KPMG will conduct interviews with manufacturers of security equipment installed at airports in Canada and the United States. KPMG may use the Confidential Information solely for the purposes of its work described above. KPMG agrees not to otherwise use Confidential Information for its own or any third party's benefit without the prior written consent of the Transportation Development Center.

ARTICLE 2
DEFINITIONS

As used herein, unless otherwise defined:
"Activity" shall mean discussions and exchange of information related to the investigative study performed by KPMG for the Transportation Development Center relating to the potential system integration of existing airport security equipment.
"Confidential Information" shall mean any business, marketing, technical, scientific or other information of any Party which, at the time of disclosure, is designated as confidential (or like designation), is disclosed in circumstances of confidence, or would be understood by the Parties, exercising reasonable business judgment, to be confidential.

"Contractor" shall mean any third party which has entered into a written agreement with **KPMG** (containing obligations of confidence substantially similar to those contained in this Agreement) to act as a consultant to **KPMG** in connection with **KPMG** projects, or to assist in the development of products or services for or on behalf of **KPMG**.

ARTICLE 3
DISCLOSURE AND USE RESTRICTIONS

Any Confidential Information received by a Party shall be retained in confidence, disclosed only to employees of that Party (and in the case of **KPMG** and its Contractors) with a need to know, and used only in connection with the Activity. The receiving Party shall use the same degree of care as it uses to protect its own confidential information of a similar nature, but no less than reasonable care, to prevent the unauthorized use, dissemination or publication of the Confidential Information. Confidential Information received by a Party under this Agreement shall not be copied without the prior written consent of the disclosing Party.

ARTICLE 4
RETURN OF CONFIDENTIAL INFORMATION

Upon request from the disclosing Party, the receiving Party shall immediately return to the disclosing Party all Confidential Information and copies thereof or if so directed by disclosing Party, shall immediately destroy such Confidential Information and all copies, and shall furnish proof of their destruction to the disclosing Party.

ARTICLE 5
EXEMPTING PROVISIONS

Neither Party shall be bound by the obligations restricting disclosure and use set forth in this Agreement with respect to Confidential Information, or any part thereof; which:

a. was known by the receiving Party prior to disclosure, as evidenced by its business records;
b. was lawfully in the public domain prior to its disclosure, or becomes publicly available other than through a breach of this Agreement;
c. was disclosed to the receiving Party by a third party provided such third party or any other party from whom such third party receives such information is not in breach of any confidentiality obligation in respect of such information;
d. is independently developed by the receiving Party, as evidenced by its business records; or
e. is disclosed when such disclosure is compelled pursuant to legal, judicial, or administrative proceeding, or otherwise required by law, subject to the receiving Party giving all reasonable prior notice to the disclosing Party to allow it to seek protective or other court orders.

ARTICLE 6
WAIVER AND ASSIGNMENT

The failure of a Party to enforce at any time or for any period of time any of the provisions of this Agreement shall not constitute a waiver of such provisions or the right of that Party to enforce each and every provision. A waiver of a failure to comply hereunder shall be effected only in writing, signed by the waiving Party and shall not constitute a waiver of any other failures to comply hereunder.

This Agreement may not be assigned in whole or in part by either Party without the prior written consent of the other Party.

ARTICLE 7
DURATION

This Agreement shall apply in respect of discussions and disclosures of information occurring during the period of one (1) year following the date of execution of this Agreement or such other period specified below:

A period beginning December 6, 1999 and ending December 6, 2000.

ARTICLE 8
PERIOD OF CONFIDENTIALITY

The period of confidentiality and restricted use for each disclosure of Confidential Information shall be ten (10) years from the date of this Agreement.

ARTICLE 9

This Agreement shall be governed by and construed in accordance with the laws of British Columbia, Canada and the laws of Canada applicable therein.

EXECUTED BY the Parties as of the day and year set out on the first page hereof.

Party	Representative (Print Name and Title)	Signature
KPMG Consulting LP	Paul Levelton	
BC Research	Dan Robinson	
Adrian Lee-Kwen	Adrian Lee-Kwen	

Copies to:
1 Transportation Development Center
1 BC Research
1 Adrian Lee-Kwen

Information and Interview Guide for Vendors and Manufacturers of Airport Security Equipment

General

1. Please provide an overview of your company and its products and services
2. What is your primary role within your organization

Security Products

1. Where do you see the market is going with respect to security related equipment particularly the type of equipment your company provides.

2. Is there a trend towards open standards in your industry. Please explain.

3. Is there an industry trend towards integration of systems to facilitate data fusion (from various sources) and if so, please explain.

4. Please provide a list of your company's equipment (model type) sold to airports in Canada and elsewhere.

5. Based on past sales, what type of equipment manufactured and sold by your organization is still in service.

6. What is the life expectancy of your equipment and what are the key determinants. What is the "mean-time-to-repair".

7. What problems if any do you foresee with the integration of equipment (e.g., old/new, different types).

8. From a vendor/manufacturer perspective, what are the major advantages/disadvantages or issues with integrating various security-related equipment.

9. What are your company's future plans with respect to airport security equipment.

10. Does your company plan to design/develop any equipment line to integrate with another in the future. If so, what is the equipment and what will it be integrated with.

11. Is your company involved in developing standard(s) with respect to airport security. If so, what are these standards.

12. Have you received feedback on your design from end users and if so, please expand.

13. Do you include usability testing with end users in your design process and if so, please explain how this is performed.

14. Under what conditions would you expect your equipment to fail. How will users know it has failed and what are the implications of equipment failure, to overall security and to the equipment itself. What did you consider as a back-up system, and what is the "mean-time-between-failures".

15. How do you anticipate that the role of the security personnel will change with future designs of your equipment (e.g., increased automation).

16. Do you envisage increased initial or periodic training for security personnel who will operate your equipment.

Additional

1. Are you aware of any research and development or white papers that your company has conducted regarding the integration of security equipment in the air transportation industry.

2. Does your company have any involvement in developing and/or monitoring industry practices in airport security.

3. What is the suggested training protocol (training provided by manufacturer, external agency or by client staff).

4. Is there a provision for training to be updated at particular intervals (e.g. annually, or as equipment is replaced).

5. What is the most important aspect of security equipment and integration from your organization's perspective

6. Does your organization involve security personnel in the design or evaluation of your technologies, and in what capacity.

7. Are ergonomics incorporated into your company's products (e.g. ease of use, comfort, flexibility, accommodation of physical differences between operators).

Technical Details

Please answer the questions that apply to your equipment. If you have an operations or maintenance manual or any other documented specifications pertaining to your equipment, please forward it to KPMG. If the information in your documentation covers the questions below, please skip the section below

Interfaces to various technologies

- Output/Display type (e.g., Audible, Single LED, Meter, Colour/mono, size of the screen (if any), dot-pitch, display resolution, refresh rate, luminescence, contrast ratios, zoom capabilities, user adjustments to format)

- Input type(s) - if any – buttons, keyboard, touch screen, mouse, voice, etc;

- Data type(s) – text, image, beep, (i.e., what is the output of the system);

- Intelligence - automated decision-making (e.g., alert security personnel to potential threat because of shape, density, etc. - what are the rules for decision-making (threat/no threat)), what is the sensitivity? (e.g., anticipated prevalence of false positives or false negatives).

- Data Resolution – identify whether it is per person, per bag or per scan (e.g., with multiple bags in the scan, like on an X-ray conveyor belt with bags placed close together);

- Time Resolution – identify whether it is continuous where one obtains an image scan line every few ms (like with an X-ray machine where multiple, consecutive lines produces an image), or whether it is just one result per bag or per passenger.

- All dynamic interactions (if any) that the operator can conduct with the equipment in analyzing the results (like zooming with an X-ray image).

- Software interface design (e.g., pull down menus, windows, icons)

- Is it possible to get access to internal data busses? (For example the displays for X-ray machines is analog. The X-ray machine scans data and internally processes it in a digital format.) Is it possible to use this digital format externally? If so, does the format follow a standard protocol or is it proprietary? (*If proprietary:* Will future machines have more open standard interfaces?)

- Do you know of any vendors that are accessing your data externally? (If so could you provide us with their contact names?)

- What is the speed of the interface (in terms of passengers/bags etc. per minute)?

Design

- Hardware: space requirements for the equipment (and servicing/maintenance of equipment), footprint, volume, weight.

- Physical requirements of the operator: (e.g., lifting, holding (i.e., wands), button pressing.)

- Power requirements.

- Environmental requirements (e.g., cooling/heating, lighting, humidity, air flow).

- Computer: operating system type, version

- Maintenance requirements (i.e., maintenance schedule, component access)

- Training requirements (i.e., individual instruction, video, printed manual, simulations, computer based training, etc.)

- Hazard analysis (i.e., types and consequences of error, backup systems, fail safe modes, designed redundancies)
- Is there a requirement to maintain security of the device from passengers (i.e., restrict viewing, physical access).
- Suggested orientation of the technology - (i.e., integration with the physical layout of the security area and security personnel.)
- What safety and emissions regulations are your systems comply with?

Thank you for your collaboration on this project.

Appendix B: Vendor Contact List

Vendor Contact List

Tim Gerchman OR Ted Tomoyasu, Mgr. New Product Development **Perkin Elmer Instruments (fmr.EG&G)** 4031 Via Oro Avenue P.O. Box 22709 Long Beach, CA 90801-5709 USA tel: (310) 816-1600 tim_gerchman@astro.egginc.com ted_tomoyasu@astro.egginc.com	Mr Jim Aldo **Vivid Technologies Inc.** 10E Commerce Way Woburn, MA 01801 USA tel: (781) 938-7800 fax: (781) 939-3996 fax: (781) 939-3993 jaldo@vividusa.com	Brian Rich, VP Engineering **Intelligent Detection Systems (IDS)** 152 Cleopatra Drive Nepean, ON K2G 5X2 Canada tel: (613) 224-1061 ext. 246 brich@idsdetection.com
Robert Madden **InVision Technologies Inc.** 7151 Gateway Boulevard Newark, CA 94560 USA tel: (510) 739-2400 fax: (510) 608-0768 tel direct: 510-739-2427 robert_madden@invision.iip.com	Scott Dennison **CEIA USA** 9177 Dutton Drive Twinsburg, OH 44087 USA tel: (330) 405-3190 fax: (330) 405-3196 sdennison@ceia-usa.com	Dan Dussault, Project Manager **Thermedics Detection, Inc.** 220 Mill Road Chelmsford, MA 01824-4178 USA tel: (978) 251-2023/2000 X 2049 fax: (978) 251-2010 ddussaul@idxinc.com
Cherif Rizkalla **Heimann Systems** 950 Bergar Laval, Quebec H7L 5A1 Canada tel: (450) 967-0010 crizkalla@heimannsystems-can.com	Al Rollins, Customer Service **BAE Inc.** 2525 Carter Drive Carrollton, TX 75006 USA tel: (972) 245-9411 fax: (972) 389-6368 arollins@bae-inc.com	Lena Kim **Barringer Technologies Inc.** 1730 Aimco Boulevard Mississauga, ON L4W 1V1 Canada tel: (905) 238-8837 fax: (905) 238-3018 lkim@barringer.com
Will Jowers **L3 Communications Security** 13161 56th Court, Suite 209-210 Clearwater, FL 33760 USA tel: (727) 556-0270 ext. 127 wil.jowers@l-3com.com	Joanne Arsenault **Ion Track Instruments** 205 Lowell Street Wilmington, MA 01887 USA tel: (978) 658-3767 fax: (978) 657-5954 jarsenault@iontrack.com	David Hack **American Science & Engineering** 829 Middlesex Turnpike Bellerica, MA 01821 USA tel: (978) 262-8700 fax: (978) 262-8803 dhack@as-e.com
Steve Wolff **Quantum Magnetics** 7740 Kenamar Court San Diego, CA 92121 USA tel: (858) 566-9200 fax: (858) 566-9388 steve.wolff@qm.com; www.qm.com		

Appendix C: Vendor Survey Responses

Contents

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InVision Technologies C-5
L3 Communications C-14
Perkin Elmer C-19

CEIA

General

1. *Please provide an overview of your company and its products and services.*

   CEIA USA has been a manufacturer of Walk through metal detection equipment for over 30 years. We are a vertically integrated ISO9001 company with over 65% of the airports in the world using our detectors. We conduct R&D, Engineering, Manufacturing and Sales and technical support from our headquarters in Arezzo, Italy, Paris, France and Cleveland, Ohio. Our efforts in airport detectors have lead to the development of new metal detection for high flow rate while maintaining very high security levels.

2. *What is your primary role within your organization.*

   Scott Dennison — Director of all operations in North and South America.

Security Products

1. *Where do you see the market is going with respect to security related equipment particularly the type of equipment your company provides.*

   US and Foreign Airlines continue to ask for our products to replace older models of other manufacturers. We see a great deal of growth in the US market with the integration of Checkpoint systems that are offered by Crown Technical Systems and ADT. We are continuing to develop aviation-related security products for higher levels of discrimination, access control and detonator detection.

2. *Is there a trend towards open standards in your industry. Please explain.*

   The problem in the US market is that the current standards for metal detection are very old. The standard currently allows the detector to miss 6 passes of the test piece out of the 36 passes required for certification. In addition, the weapons used for certification do not consider newer models of weapons being sold. There is no measure for field uniformity, discrimination and immunity to interference. However, the Canadian Government has done extensive testing on new standards and the US Government should look at what Transport Canada has done.

3. *Is there an industry trend towards integration of systems to facilitate data fusion (from various sources) and if so, please explain.*

   The industry is moving closer towards integration. Recently Delta Airlines has initiated a project in Atlanta to better capture data and put it to some useful purpose. Our equipment has the ability to be networked to a central location to provide passenger counts, alarm rates, etc., but most airlines do not take advantage of this information.

4. *Please provide a list of your company's equipment (model type) sold to airports in Canada and elsewhere.*

   The models most often selected are the 02PN10 (all airports in Canada), PMD2 and the Elliptic.

5. *Based on past sales, what type of equipment manufactured and sold by your organization is still in service.*

   All of our models PMD2, PMD1, 02PN10, 02PN8-HIPE, 02PN8HIPE/HD and the Elliptic are in operation.

6. *What is the life expectancy of your equipment and what are the key determinants. What is the "mean-time-to-repair".*

   MTBF is 15 years. Life expectancy can exceed this but technology is the driving factor in replacement.

7. *What problems if any do you foresee with the integration of equipment (e.g., old/new, different types).*

   We do not foresee any problems.

8. *From a vendor/manufacturer perspective, what are the major advantages/disadvantages or issues with integrating various security-related equipment.*

   The major advantage is that the checkpoint is designed to allow maximum flow rate while taking into consideration environmental effects that can cause problems with electromagnetic fields. Currently this is not taken into consideration.

9. *What are your company's future plans with respect to airport security equipment.*

   We are working with all the airlines and system integrators on building the metal detector into the checkpoint structure so that it is transparent. This will provide a more ascetically pleasing approach to airport security.

10. *Does your company plan to design/develop any equipment line to integrate with another in the future. If so, what is the equipment and what will it be integrated with.*

    We have already developed and patented the first metal detector that reads an access control card on the fly. This is a major advancement in that you have high flow rate with metal detection and access control combined. The product is called MET Card ID and can be seen on our web site http:///www.ceia-usa.com.

11. *Is your company involved in developing standard(s) with respect to airport security. If so, what are these standards.*

    We worked closely with Transport Canada and are working with the FAA. We have worked with many other countries and government agencies on the development of realistic metal detection standards.

12. *Have you received feedback on your design from end users and if so, please expand.*

    Yes, particularly with the United States Secret Service. We developed special models for their unique needs and CEIA is the only metal detector used by this agency. We are always open to input from our customers on special designs.

13. *Do you include usability testing with end users in your design process and if so, please explain how this is performed.*

    Yes, we receive feedback from the users about durability and functions and then make changes as necessary.

14. *Under what conditions would you expect your equipment to fail. How will users know it has failed and what are the implications of equipment failure, to overall security and to the equipment itself. What did you consider as a back-up system, and what is the "mean-time-between-failures".*

    We have such a low failure rate due to our construction using SMT and ASIC's that this is not a problem. All units have an auto test function and if there is a failure it is displayed on the control head.

15. *How do you anticipate that the role of the security personnel will change with future designs of your equipment (e.g., increased automation).*

    We believe that with the use of the metal detector connected to such products as the RAPOR door there will be fewer security personnel needed.

16. *Do you envisage increased initial or periodic training for security personnel who will operate your equipment.*

    No

Additional

1. *Are you aware of any research and development or white papers that your company has conducted regarding the integration of security equipment in the air transportation industry.*

    Yes

2. *Does your company have any involvement in developing and/or monitoring industry practices in airport security.*

    Yes

3. *What is the suggested training protocol (training provided by manufacturer, external agency or by client staff).*

    Technical Training for maintenance. Usually one time for about 4 hours.

4. *Is there a provision for training to be updated at particular intervals (e.g. annually, or as equipment is replaced).*

    No

5. *What is the most important aspect of security equipment and integration from your organization's perspective.*

    The most important aspect is that the purchasers realize that you have to pay for technology.

6. *Does your organization involve security personnel in the design or evaluation of your technologies, and in what capacity.*

    Yes

7. *Are ergonomics incorporated into your company's products (e.g. ease of use, comfort, flexibility, accommodation of physical differences between operators).*

    Yes

Technical Details

Please answer the questions that apply to your equipment. If you have an operations or maintenance manual or any other documented specifications pertaining to your equipment, please forward it to KPMG. If the information in your documentation covers the questions below, please skip the section below.

This information will be provided at a later date when we have some idea as to your intentions.

InVision Technologies

General

1. *Please provide an overview of your company and its products and services*

   InVision Technologies develops, manufactures, markets and supports explosive detection systems based on advanced computed tomography (CT) technology for civil aviation security. Today, more than 180 FAA-certified CTX explosive detection systems have been shipped worldwide to provide the traveling public with the best security against terrorism available. The company also develops, manufactures, markets and supports CT-based systems for other applications including drug detection.

   InVision's wholly owned subsidiary, Quantum Magnetics, develops and commercializes products based on various RF technologies, including low-cost products for explosive detection and other commercial applications. Additional information about InVision can be obtained on the company's web site at: http://www.invision-tech.com.

2. *What is your primary role within your organization*

   Bob Madden – responsible for business development and customer relations in North America.

Security Products

1. *Where do you see the market is going with respect to security related equipment, particularly the type of equipment your company provides.*

   Short Term (0-5 years): The market appears to be flat for deploying advanced security equipment, driven primarily by the large costs of the technology and adding infrastructure to already crowded airports, as well as the apparent decline of terrorist attacks against civil aviation. A flat market will mean that companies can invest less of their own R&D money into product cost reduction and improvements. Funding for such improvements will need to come from government agencies.

   Longer Term (5-10 years): We see the long-term market strengthening as world airports and aviation administrations move toward the goal of 100% checked baggage screening. This will be aided by increased air travel forcing airports to redesign/ build new terminals. As these proceed, the airports will incorporate the necessary space and infrastructure into their designs. This will further the demand for certified EDS and increase the support base for a larger deployment.

2. *Is there a trend towards open standards in your industry. Please explain.*

   No. Explosive detection systems used in US airports or with US carriers must meet strict Federal Aviation Administration certification standards. However, these standards are classified. Though ECAC has its own standards, which are similar to the FAA's, they are not being enforced by the member states who are free to deploy a wide range of technologies and human oriented processes for screening hold baggage. Furthermore, the FAA has adopted a different screening strategy in the US, using CAPS instead of 100% HBS.

3. *Is there an industry trend towards integration of systems to facilitate data fusion (from various sources) and if so, please explain.*

The market is highly segmented with each segment having its own approach:

US Large Airports:	Some integration, especially in newly constructed terminals
US Medium/Small Airports:	Little/no integration of EDS. Likely will not occur until implementation costs have dramatically reduced
Overseas Large Airports:	Mostly integrated systems
Overseas Medium Airports:	Primarily integrated systems
Overseas Small Airports:	Primarily distributed small systems with large degree of hand search.

Where industry is moving towards integrated solutions, the trend will be for EDS machines to communicate with airport BHS to exchange bag-specific information for tracking purposes. Some customers have indicated a future desire to integrate a computer-profiling system with decisions (and images) collected by integrated explosive detection systems. Passenger and passenger baggage information will be collected and displayed on a single screen.

4. *Please provide a list of your company's equipment (model type) sold to airports in Canada and elsewhere.*

Explosive Detection Systems:

CTX 2500	Mobile system deployed by US Customs
CTX 5000 SP	~75 deployed throughout US, Europe, Africa and Asia
CTX 5500 DS	~100 deployed throughout US, Europe, Africa and Asia
CTX 9000 DSi	~10 to be deployed by Q2, 2000 in US and Asia

5. *Based on past sales, what type of equipment manufactured and sold by your organization is still in service.*

Over 180 systems deployed. Many of the CTX 5000 SP systems were upgraded to CTX 5500 DS configurations.

6. *What is the life expectancy of your equipment and what are the key determinants. What is the "mean-time-to-repair".*

Life expectancy is directly related to three key factors:

- Changing the state of the art with newer technology
- Major mechanical components are designed to last ~10 years (gantry bearing)
- Obsolescence of computer/electronic systems. CTX provides substantial capability to upgrade such systems, however this can not be guaranteed indefinitely.

Mean time to repair: Unavailable. We have mean time to response, mean time to arrive (Field Service) and mean time between failures.

7 *What problems if any do you foresee with the integration of equipment (e.g., old/new, different types).*

- Large variety of different bag types
- Smooth mechanical integration with the conveyor system is essential
- Well-educated BHS contractor force
- EDS Manufacturer involvement at the earliest stages of the design is essential
- Design needs to incorporate redundancy
- For overseas screening, a reduction in the number of screening levels is needed to simplify design/implementation

8. *From a vendor/manufacturer perspective, what are the major advantages/disadvantages or issues with integrating various security-related equipment.*

- High cost to integrate machines (about 2x cost of the EDS equipment on its own)
- Large amount of infrastructure and space needed to support integrated machines
- Lengthy process to design, optimize, build, install, commission, and tune integrated EDS
- Screening is removed from the passenger, making bag reconciliation difficult
- Screening is performed closer to departure time – increases the burden on the operator to make faster, less effective decisions
- High throughput forces operator to make faster decisions – this is counter to the goal of good security
- Reliability – if the system crashes, the line becomes inactive

9. *What are your company's future plans with respect to airport security equipment.*

Reduce false alarm rate to ensure that operators are focussed on the most suspicious bags.

Design and build products that meet the required market segments:

- Improved speed/integration capability for large airport needs
- Lower throughput, smaller, lower cost EDS for smaller airports

10. *Does your company plan to design/develop any equipment line to integrate with another in the future. If so, what is the equipment and what will it be integrated with.*

Looking at complementary, cost-effective technologies that can reduce false alarm rates for different applications. Options include:

- Quadrupole Resonance EDS
- X-ray diffraction systems
- Vapor detection systems

12. *Have you received feedback on your design from end users and if so, please expand.*

User interface was developed based on feedback from a variety of customers during initial beta trials.

Customer feedback during initial installations was critical in setting the key design parameters for the CTX 9000, namely the 1 m wide belt, high throughput.

FAA feedback has been paramount during all phases of development and improvements, especially in the area of automatic detection

13. *Do you include usability testing with end users in your design process and if so, please explain how this is performed.*

Yes. Customers and users are often invited to focus groups to discuss potential improvements. The FAA has human factors professionals who give guidance for improving system design.

The company has used a mixture of focus groups, customer surveys and one-on-one meetings to determine the design direction of various products. Future system designs will incorporate feedback from users of existing equipment.

14. *Under what conditions would you expect your equipment to fail. How will users know it has failed and what are the implications of equipment failure, to overall security and to the equipment itself. What did you consider as a back-up system, and what is the "mean-time-between-failures".*

We would expect CTX systems to fail if they were operated outdoors, where the systems are exposed to excessive temperatures and moisture. Much of the electronic equipment is temperature and humidity sensitive. CTX 9000 DSi systems are sealed and have on-board air conditioners to cool sensitive components, making them more reliable in rigorous applications.

Wet conveyor belts would allow bags to slip during scanning. This causes machine faults. Belts must remain dry to maintain tackiness.

15. *How do you anticipate that the role of the security personnel will change with future designs of your equipment (e.g., increased automation).*

An explosives detection system is only as strong as its weakest link. That link is usually the human operator, who must make decisions on potential threats. Future machine designs will need to be more automated. Operator interface modules will not only display given bag information, but will "coach" operators through threat resolution decisions. Computer algorithms will recognize threat characteristics and instruct operators on which tools and functions must be chosen to determine the validity of a threat. This "coaching" will exploit the system's detection capabilities and guide operators through established threat resolution protocols.

The deployment of EDS equipment changes the number of operators needed to perform security. There is an opportunity to deploy fewer operators with more substantial responsibilities and compensation than those currently used. This has not yet been appreciated by the security provider companies, who continue to hire personnel based on their current skill set needs. It is becoming clear to regulators that a higher standard of operator is needed for this type of equipment if end-to-end detection is to remain high. It is also clear that the turnover rate of operators (at least in the US) needs to be reduced.

InVision also proposes improved selection criteria and standardized training for all CTX system operators.

16. *Do you envisage increased initial or periodic training for security personnel who will operate your equipment.*

InVision hopes to minimize the costs associated with maintaining EDS. One cost reduction involves operator training. Future machines, with simple user interface designs, will be more user-friendly. Periodic training and testing will still be necessary, as employee turnover will likely remain high. The training simulator will offer effective training and testing without costly machine down time.

We expect that there will be fewer security personnel needed and that they will need more in-depth training. While the mechanics of machine operations will remain straightforward (no more complex

than current systems), the training will need to center around using technology to identify the threat. Increased training on the nature and configuration of threat devices will be likely.

Additional

1. *Are you aware of any research and development or white papers that your company has conducted regarding the integration of security equipment in the air transportation industry.*

   We have written numerous articles and applications papers on this subject, including how to assess detection capability, operational requirements and determining lifetime costs.

2. *Does your company have any involvement in developing and/or monitoring industry practices in airport security.*

   Yes, we often attend industry roundtable discussions, National Safe Skies Association meetings, ECAC meetings, etc.

3. *What is the suggested training protocol (training provided by manufacturer, external agency or by client staff).*

   The suggested training protocol is through InVision's *Operator Training Course*. This course lasts 10 days and includes both classroom lecturing and on-the-scanner instruction. An alternative would include training by an external agency that has undergone InVision's *Instructor Training Course*.

   InVision recommends the implementation and monitoring of Threat Image Projection technology (TIP) to assess operator on-the-job performance. InVision also recommends using an off-line database to pretest operators before they start their shift. Such a test can be performed using a stored data set of bags and can be performed either on the scanner, or using a low cost CTX Simulator.

4. *Is there a provision for training to be updated at particular intervals (e.g. annually, or as equipment is replaced).*

   Solely up to customer.

5. *What is the most important aspect of security equipment and integration from your organization's perspective?*

   Design of an end-to-end detection system that meets customer and regulator needs. The system must have effective detection and sufficient speed, while minimizing operating costs as these usually exceed the up-front investment after only 2-3 years. The other important aspect of security equipment is its users. Operators must be properly trained, motivated and monitored to effectively use the equipment. InVision is making strong efforts to address all three of these aspects.

6. *Does your organization involve security personnel in the design or evaluation of your technologies, and in what capacity.*

   InVision has hired several former CTX operators into various marketing and training positions. In addition to providing a unique perspective, these personnel drive the input from the customer base and incorporate needed features into the product design.

   In addition, the Tender process requires the addition of features that customers expect. We hold frequent meetings with our customers to assess their needs.

CTX systems undergo substantial scrutiny prior to purchase. Different regulators evaluate our systems via a formal testing process. In this testing, the machine must pass minimal detection, false alarm and throughput criteria.

7. *Are ergonomics incorporated into your company's products (e.g. ease of use, comfort, flexibility, accommodation of physical differences between operators).*

   Yes. InVision has hired Human Factors professionals as employees and consultants. These consultants have spent substantial time with operators in the field in order to better layout keyboards, screens to improve performance and to assure that ergonomic needs are met. This has lead to a substantial redesign of the user interface and control console for the CTX 5500 relative to the original CTX 5000.

Technical Details

Please answer the questions that apply to your equipment. If you have an operations or maintenance manual or any other documented specifications pertaining to your equipment, please forward it to KPMG. If the information in your documentation covers the questions below, please skip the section below.

Interfaces to various technologies

1. *Output/Display type (e.g., Audible, Single LED, Meter, Colour/mono, size of the screen (if any), dot-pitch, display resolution, refresh rate, luminescence, contrast ratios, zoom capabilities, user adjustments to format)*

   See spec sheets

2. *Input type(s) - if any – buttons, keyboard, touch screen, mouse, voice, etc;*

   See User's Guide

3. *Data type(s) – text, image, beep, (i.e., what is the output of the system);*

   See User's Guide

4. *Intelligence - automated decision-making (e.g., alert security personnel to potential threat because of shape, density, etc. - what are the rules for decision-making (threat/no threat)), what is the sensitivity? (e.g., anticipated prevalence of false positives or false negatives).*

   As a bag enters the EDS for screening, the machine acquires a scan projection X-ray image. A computer analyzes the image and determines locations requiring CT. A rapid conveyor transfers the bag to the CT module, where a rotating X-ray takes "CT slices" of locations containing potential explosives. The system uses sophisticated computer algorithms to analyze objects and compare their CT properties with those of known explosive groups. If a match is found for an item with sufficient mass, the system alarms and displays the object on the CT screen. The potential explosives and bomb components are highlighted on both the SP and CT screens. The operator then uses the images to make a confident, final decision. The detailed algorithms used to inspect the SP and CT data are both company proprietary and classified by the US government.

5. *Data Resolution – identify whether it is per person, per bag or per scan (e.g., with multiple bags in the scan, like on an X-ray conveyor belt with bags placed close together);*

   Per Bag

6. *Time Resolution – identify whether it is continuous where one obtains an image scan line every few ms (like with an X-ray machine where multiple, consecutive lines produces an image), or whether it is just one result per bag or per passenger.*

   One set of images (SP and CT) per bag.

7. *All dynamic interactions (if any) that the operator can conduct with the equipment in analyzing the results (like zooming with an X-ray image).*

   The operator has many available tools to analyze results. Operators can ZOOM, ADJUST CONTRAST, TAKE ADDITIONAL CT SLICES, REMOVE HIGHLIGHTING COLOR, CHANGE IMAGE CONTRAST, INVERT IMAGE COLORING (Black to White), SAVE IMAGES, PRINT IMAGES, ETC. – Look in the User's Manual.

8. *Software interface design (e.g., pull down menus, windows, icons)*

   Mixture of buttons and display windows for images, bag information, threat information and system status (bag locations)

9. *Is it possible to get access to internal data busses? (For example the displays for X-ray machines is analog. The X-ray machine scans data and internally processes it in a digital format.) Is it possible to use this digital format externally? If so, does the format follow a standard protocol or is it proprietary?* (If proprietary: *Will future machines have more open standard interfaces?)*

   InVision software engineers can access internal data busses. The format is proprietary. Operators and Supervisors are denied access to this information.

   Machine data and operator performance data (TIP) are recorded on disk. This can be downloaded via modem if the remote user has access to the security protocols.

   Image data can be saved by the operator at the operator's discretion:
   - Image data (InVision Proprietory)
   - Screen display (Sun Raster or TIFF format)
   - Scan Converter: allows direct video conversion of the CTX displays to standard composite video in either PAL or NTSC format. This requires additional hardware.

10. *Do you know of any vendors that are accessing your data externally? (If so could you provide us with their contact names?)*

    No

11. *What is the speed of the interface (in terms of passengers/bags etc. per minute)?*

    Depends on bag type, destination and complexity. The following are data recorded at FAA certification using a specified bag set (excluding operator decision time):
    - CTX 9000: 542 bags/hour.
    - CTX 5500: 362 bph
    - CTX 2500: 128 bph

Design

1. *Hardware: space requirements for the equipment (and servicing/maintenance of equipment), footprint, volume, weight.*

   See Spec Sheets and User's Guide

2. *Physical requirements of the operator: (e.g., lifting, holding (i.e., wands), button pressing.)*

   See User's Guide

3. *Power requirements.*

   See Spec Sheet

4. *Environmental requirements (e.g., cooling/heating, lighting, humidity, air flow).*

   See Spec Sheet

5. *Computer: operating system type, version*

   See Spec Sheet

6. *Maintenance requirements (i.e., maintenance schedule, component access)]*

   CTX machines were designed for unhindered access to components for upgrade and repair. Maintenance is required on a quarterly basis as a minimum. InVision offers several maintenance plans to suit the varying needs of its customers.

7. *Training requirements (i.e., individual instruction, video, printed manual, simulations, computer based training, etc.)*

   Training for 10 operators is included with each sale. This training course includes the following:
   - Basic operations of CTX 5500 DS
   - CT image interpretation
   - CTX alarm resolution (subject to FAA approval)
   - Multimedia classroom lecture and on-the-scanner training (OST)
   - 5-day course for up to ten students, at Purchaser's site or at InVision Training Center
   - Instruction provided in English

   InVision offers supplementary training courses to train new operators and condition current operators.

8. *Hazard analysis (i.e., types and consequences of error, backup systems, fail safe modes, designed redundancies)*

Fault Reset:	Operator can clear software faults/reset upon jammed bags etc.
Software restart:	Operator can restart hung software
Emergency Stop:	Either Category 0 or 1 emergency stops: Disconnects all power to the scanner. 0 – disconnects power, allows components to spin down (CTX 2500 and 5500) 1 – actively brakes moving components, then shuts off power (CTX 9000)

9. *Is there a requirement to maintain security of the device from passengers (i.e., restrict viewing, physical access).*

   The X-ray system is safe to use in a public area. People should not put body parts inside the machine during operation. Many airlines/airports often erect restrictive barriers to the machine when it is operated in a public part of the airport terminal.

10. *Suggested orientation of the technology - (i.e., integration with the physical layout of the security area and security personnel.)*

The EDS shall consist of a high throughput, quick detection device that is integrated with the Airport's BHS. Baggage will be manually or automatically routed to the System for X-ray and computed tomography image processing to accurately and quickly detect materials with explosive parameters. System scanning devices will be physically installed on baggage handling system conveyor belts and shall be used for "Level 1" and "Level 2" screening. The specified EDS shall be of a compact design, not to exceed six meters length, when installed in the BHS. Through software modifications, the System shall be configurable to automatically detect contraband including illegal drugs.

11. *What safety and emissions regulations are your systems comply with?*

FDA 21 CFR 1020.40

Conforms to CE Directives and Standards

L3 Communications

General

1. *Please provide an overview of your company and its products and services*

   L-3 Communications is a leading merchant supplier of secure communications technology, instrumentation, space and wireless products. Customers include the US Department of Defense, selected US government agencies, aerospace and defense prime contractors and telecommunications and cellular customers. It is a publicly traded company on the New York Stock Exchange and comprises an organization of over 6,500 employees and $1.4B in annual sales.

   Security Systems Division of L-3 Communications was formed as a core group specializing in explosive detection systems. This group is responsible for the design, development and certification of the eXaminer 3DX 6000 Explosive Detection System (EDS) to meet US FAA high volume, integrated operation airport requirements.

2. *What is your primary role within your organization*

   Will Jowers — Director of Programs, Security Systems Division. As such, I have responsibility for fulfilling domestic US FAA and international contract requirements for the eXaminer 3DX 6000 system.

Security Products

1. *Where do you see the market is going with respect to security related equipment particularly the type of equipment your company provides.*

   L-3 Communications, Security Systems Division is delivering the eXaminer 3DX 6000 to the US FAA for installation in US international airports. The current contract is for up to 60 such systems. L-3 has also delivered and installed EDS systems in Aeroporto di Roma in fully integrated operations. Other international contracts are pending.

   In addition, L-3 is working under a grant from the US FAA to develop the ARGUS EDS system. ARGUS will be an EDS with reduced throughput requirements for smaller airport operations.

2. *Is there a trend towards open standards in your industry. Please explain.*

   No specific trends noted.

3. *Is there an industry trend towards integration of systems to facilitate data fusion (from various sources) and if so, please explain.*

   L-3 Communications is not specifically pursuing data fusion as part of this product line.

4. *Please provide a list of your company's equipment (model type) sold to airports in Canada and elsewhere.*

   eXaminer 3DX 6000 explosive detection system.

5. *Based on past sales, what type of equipment manufactured and sold by your organization is still in service.*

   eXaminer 3DX 6000

6. *What is the life expectancy of your equipment and what are the key determinants. What is the "mean-time-to-repair".*

   The eXaminer 3DX 6000 is projected to have a 10 year service life based on operating 16 hours per day. The projected Mean-time-between-failure is approximately 610 hours.

7. *What problems if any do you foresee with the integration of equipment (e.g., old/new, different types).*

   Issues with handling and spacing of bags in an integrated, high throughput environment.

8. *From a vendor/manufacturer perspective, what are the major advantages/disadvantages or issues with integrating various security-related equipment.*

   Major disadvantage is the difficulty in meeting diverse system requirements and system capabilities.

9. *What are your company's future plans with respect to airport security equipment.*

   L-3 Communications, Security Systems Division plans to remain active in the airport security business as a leading supplier of explosive detection systems.

10. *Does your company plan to design/develop any equipment line to integrate with another in the future. If so, what is the equipment and what will it be integrated with.*

    L-3 Communications has no specific plans to develop a unique integration with another system at this time. Requirements will be driven by customer and security requirements.

11. *Is your company involved in developing standard(s) with respect to airport security.* If so, what are these standards.

    No.

12. *Have you received feedback on your design from end users and if so, please expand.*

    L-3 Communications has received feedback on system design from the FAA Technical Center users, and from operators using the system in Aeroporto di Roma. The pending installation in Dallas Fort Worth International Airport will provide additional detailed feedback, and installation and operations options.

13. *Do you include usability testing with end users in your design process and if so, please explain how this is performed.*

    Proposed system designs are demonstrated to customers and inputs fed back into final system designs and configurations.

14. *Under what conditions would you expect your equipment to fail. How will users know it has failed and what are the implications of equipment failure, to overall security and to the equipment itself. What did you consider as a back-up system, and what is the "mean-time-between-failures".*

    Parts and sub-system wear and failure. Failure modes are identified and the operator is automatically notified through screen messages. Failure modes are identified as soon as practical to minimize system damage and down time. Projected mean-time-between-failure for the eXaminer is 610 hours.

15. *How do you anticipate that the role of the security personnel will change with future designs of your equipment (e.g., increased automation).*

    Increased automation will reduce the personnel requirements to operate and to maintain the system.

16. *Do you envisage increased initial or periodic training for security personnel who will operate your equipment.*

    L-3 has developed an initial and follow-on operator training programs.

Additional

1. *Are you aware of any research and development or white papers that your company has conducted regarding the integration of security equipment in the air transportation industry.*

    L-3 has no specific R&D activities involving integration of security equipment.

2. *Does your company have any involvement in developing and/or monitoring industry practices in airport security.*

    No.

3. *What is the suggested training protocol (training provided by manufacturer, external agency or by client staff).*

    Suggested protocol is manufacturer training. Training programs have been developed and are available for the customers.

4. *Is there a provision for training to be updated at particular intervals (e.g. annually, or as equipment is replaced).*

    A follow-on training and a re-training program are planned. Specific training interval is to be determined by the end user.

5. *What is the most important aspect of security equipment and integration from your organization's perspective*

    Security equipment availability, operations reliability, and utility. The systems must be available when needed, must perform within high confidence levels and displays must be capable of being interpreted without extensive training.

6. *Does your organization involve security personnel in the design or evaluation of your technologies, and in what capacity.*

   L-3 Communications maintains an ongoing dialogue with US FAA Security Equipment and R&D product teams in system design, developn ent and testing.

7. *Are ergonomics incorporated into your company's products (e.g. ease of use, comfort, flexibility, accommodation of physical differences between operators).*

   Yes. System is designed to be operated by physically different operators. Displays are optimized for ease of use and to provide maximum operator flexibility.

Technical Details

Please answer the questions that apply to your equipment. If you have an operations or maintenance manual or any other documented specifications pertaining to your equipment, please forward it to KPMG. If the information in your documentation covers the questions below, please skip the section below

Interfaces to various technologies

1. *Output/Display type (e.g., Audible, Single LED, Meter, Colour/mono, size of the screen (if any), dot-pitch, display resolution, refresh rate, luminescence, contrast ratios, zoom capabilities, user adjustments to format)*

   Display is by color monitor. Details are included in systems Operators Guide.

2. *Input type(s) - if any – buttons, keyboard, touch screen, mouse, voice, etc;*

   Input is via customized keyboard.

3. *Data type(s) – text, image, beep, (i.e., what is the output of the system)*

   Data output is via image and text.

4. *Intelligence - automated decision-making (e.g., alert security personnel to potential threat because of shape, density, etc. - what are the rules for decision-making (threat/no threat)), what is the sensitivity? (e.g., anticipated prevalence of false positives or false negatives).*

   Automated decision making is used to determine probable presence of explosive substances. Details of the decision-making process and sensitivities are not disclosable.

5. *Data Resolution – identify whether it is per person, per bag or per scan (e.g., with multiple bags in the scan, like on an X-ray conveyor belt with bags placed close together);*

   Potential explosives are resolved as objects within individual bags. Multiple objects can be discerned and displayed.

6. *Time Resolution – identify whether it is continuous where one obtains an image scan line every few ms (like with an X-ray machine where multiple, consecutive lines produces an image), or whether it is just one result per bag or per passenger.*

   Each bag is displayed individually and each object within the bag can be examined individually. System operation is continuous, and the image for the next bag in the queue is available as soon as the "current" bag image is cleared.

7. *All dynamic interactions (if any) that the operator can conduct with the equipment in analyzing the results (like zooming with an X-ray image).*

   Orientation, zoom in, zoom out, color selection, color deletion, gray scale, background (black on white/white on black), rotation, and cross sectional slice selection are all available.

8. *Software interface design (e.g., pull down menus, windows, icons)*

   Pull down windows and menus.

9. *Is it possible to get access to internal data busses? (For example the displays for X-ray machines is analog. The X-ray machine scans data and internally processes it in a digital format.) Is it possible to use this digital format externally? If so, does the format follow a standard protocol or is it proprietary?* (If proprietary: *Will future machines have more open standard interfaces?)*

   Currently, access to the internal data busses is not permitted.

10. *Do you know of any vendors that are accessing your data externally? (If so could you provide us with their contact names?)*

    N/A

11. *What is the speed of the interface (in terms of passengers/bags etc. per minute)?*

    The eXaminer is designed to operate at speeds of up to 500 bags per hour.

Design

1. *Hardware: space requirements for the equipment (and servicing/maintenance of equipment), footprint, volume, weight.*

   Details included in system Operator's Guide

3. *Power requirements.*

   Details included in system Operator's Guide

4. *Environmental requirements (e.g., cooling/heating, lighting, humidity, air flow).*

   Details included in system Operator's Guide

5. *Computer: operating system type, version*

   Details included in system Operator's Guide

Perkin Elmer

General

1. *Please provide an overview of your company and its products and services.*

   Perkin Elmer is a $1.6 billion company. PE sells security equipment, medical equipment, opto-electronics systems, etc. The company recently acquired Vivid Technologies to widen the portfolio of security related equipment.

2. *What is your primary role within your organization.*

   Ted Tomoyasu — Director of Strategy and New Product Development.

Security Products

1. *Where do you see the market is going with respect to security related equipment particularly the type of equipment your company provides.*

   Equipment will be more automized to limit user intervention and interpretation of results. We have acquired Vivid because it allows us to provide solutions for Level 1 and Level 2 screening. There is also a significant collaboration between manufacturers in our industry (e.g., metal detectors).

   The industry is a mature industry. We have just won a contract to supply an airport in South Korea with new X-ray machines. This type of opportunity will happen once in 5 years. There is a finite number of airports and government buildings that require security sensors.

2. *Is there a trend towards open standards in your industry. Please explain.*

   Different manufacturers are still using their proprietary format for imaging. They may, however, be using the same operating systems (Linux, Win NT, Windows 98 etc.) and the same network protocols. If companies would develop the solutions with one standard in mind they would all evolve the same way.

3. *Is there an industry trend towards integration of systems to facilitate data fusion (from various sources) and if so, please explain.*

   We have teamed with L3 Communications for the airport in Rome. Our system can communicate with the baggage handling system (BHS) and link all checkpoints or levels of security. The industry trend is that an operator becomes less important in the analysis of the information delivered by the equipment.

4. *Please provide a list of your company's equipment (model type) sold to airports in Canada and elsewhere.*

   We have sold equipment from the entire product line to the Government of Canada and government institutions.

5. *Based on past sales, what type of equipment manufactured and sold by your organization is still in service.*

   There are a large number of old pieces of equipment still in service. I cannot provide you with more specific information.

6. *What is the life expectancy of your equipment and what are the key determinants. What is the "mean-time-to-repair".*

   The FAA is currently purchasing new X-ray machines to replace other devices. The FAA wants to raise the security level provided at the airports. Systems can last for more than 15 years. Their service life certainly exceeds their useful life. By that I mean technology evolution makes a piece of equipment obsolete before the equipment reaches the end of its life. We have to be able to detect smaller explosive devices and other threats. The meantime to repair is about 3 years (conservative estimate). This number is based on 12,000 installations.

7. *What problems if any do you foresee with the integration of equipment (e.g., old/new, different types).*

   As equipment evolves there will be new hardware and software. Frequently, old hardware is not upwards compatible. For example, a 15-year old piece of equipment will not have Ethernet access.

8. *From a vendor/manufacturer perspective, what are the major advantages/disadvantages or issues with integrating various security-related equipment.*

   Different operating systems (OS) will make it difficult to integrate the various systems. Using a common OS would allow an easier integration. Any attempt to integrate the various systems has to be manufacturer driven. As I explained before we are working with a number of other equipment manufacturers (BHS, metal detectors and explosive detection systems).

9. *What are your company's future plans with respect to airport security equipment.*

   The acquisition of Vivid is an indication of what will happen. We want to provide Level 1 and 2 security equipment. Our plans reflect a trend in the industry (i.e., consolidation of manufacturers that provide solutions). Realistically, there are only 3 manufacturers of X-ray systems for airport security around the world.

10. *Does your company plan to design/develop any equipment line to integrate with another in the future. If so, what is the equipment and what will it be integrated with.*

    Yes. Level 1 and 2 security equipment.

11. *Is your company involved in developing standard(s) with respect to airport security. If so, what are these standards.*

    We cooperate with the FAA but do not set standards.

12. *Have you received feedback on your design from end users and if so, please expand.*

    We have received a significant amount of feedback from the field. We use this feedback in the design the type of options we provide to our customers (e.g., color and b/w monitors, one of multiple monitors, etc.).

13. *Do you include usability testing with end users in your design process and if so, please explain how this is performed.*

    We have done a significant amount of usability testing in the development phase of the project. For beta testing we usually go to some of the busiest airports.

    Our equipment follows the industry standard on coloring threats: orange for organic material, fluorescent green for dense material (other manufacturers use black)

    The X-ray imaging system is FAA approved (there are only 3 manufacturers at the moment with this approval). Our equipment can process 1000 bags/hour for a Level 1 application and approximately 600 bags/hour for a Level 2 application (target is to increase this to 1000 as well).

14. *Under what conditions would you expect your equipment to fail. How will users know it has failed and what are the implications of equipment failure, to overall security and to the equipment itself. What did you consider as a back-up system, and what is the "mean-time-between-failures".*

    All equipment will fail under the following scenarios: faulty line power, humid environment with condensation and corrosion, high dust environment. There are safeguards built into the system to alert the user of problems.

15. *How do you anticipate that the role of the security personnel will change with future designs of your equipment (e.g., increased automation).*

    There will be more automatic detection. Current image processing is limited by the available CPU and costs associated for image processing. Fully automated systems may also have an increased false alarm rate.

    The FAA recently issued a 250-page document that will raise the bar for the security personnel (i.e., training, basic knowledge, etc.).

16. *Do you envisage increased initial or periodic training for security personnel who will operate your equipment.*

    On-the-job training as well as the now mandatory Threat Image Project (TIP) will keep the security personnel on their toes. We provide a week-long training session and an additional one-day field course.

Additional

1. *Are you aware of any research and development or white papers that your company has conducted regarding the integration of security equipment in the air transportation industry.*

    No.

2. *Does your company have any involvement in developing and/or monitoring industry practices in airport security.*

    No.

3. *What is the suggested training protocol (training provided by manufacturer, external agency or by client staff).*

    Typically class room training session followed by a one-day seminar in the field.

4. *Is there a provision for training to be updated at particular intervals (e.g. annually, or as equipment is replaced).*

   TIP will be used to score the performance of the operators and assess training needs.

5. *What is the most important aspect of security equipment and integration from your organization's perspective*

   Explained previously.

6. *Does your organization involve security personnel in the design or evaluation of your technologies, and in what capacity.*

   Limited to surveys and beta tests.

7. *Are ergonomics incorporated into your company's products (e.g. ease of use, comfort, flexibility, accommodation of physical differences between operators).*

   There are a minimum number of buttons (many users are confused by too many options). The GUI is based on historical knowledge. Our company has not conducted any recent studies or surveys. All machines have options for sitting or standing.

Thank you for your collaboration on this project.

Appendix D: Vendor Interview Notes

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American Science & Engineering

Interviewers: Dan Robinson, Adrian Lee-Kwen
Interviewees:
Richard (Dick) Sesnewicz, VP Business Development
Bill Baukus, Manager Technical Marketing

Overview of AS&E

AS&E market backscatter X-ray technology for "anomaly detection". Products include parcel systems, pallet oriented systems, vehicle mounted mobile search, body search and baggage search (101ZZ/101Z).

AS&E does not currently service airports in North America. The only airports with AS&E products are in the Far East, where AS&E systems are used for both checked and carry-on bag screening. AS&E products are approximately twice the cost of competing transmission X-ray systems. Cost and poor return on market investment were indicated as the main reasons for lack of use in N.A. airports. Clients include the U.S. Whitehouse, NSA, FBI and CIA.

Compete with transmission X-ray technologies, such as Heimann, Vivid, Rapid Scan and Astrophysics. Feel that Vivid has the best competing product because of the pulsed source.

Products and Process

Discussed AS&E technology (Z Backscatter) relative to competing transmission X-ray and TEDS.

Transmission is 90% effective for weapon detection and dual scan can detect organics that are not well hidden. Many of the transmission X-ray systems utilize a colour image, which AS&E believes is not useful and can be misleading by displaying incorrect colours. CTX500 produces a high number of false positives and doesn't identify chemical or biological weapons. A hidden GLOC17 is not detectable by transmission X-ray. Sesnewicz has a test suitcase that is used to fool transmission X-ray systems. The use of a dual view image (Astrophysics Z-scan) provides better spatial clues than single image.

TEDS are complementary systems, but one could seal and clean a container and there would be no detectable trace. The Z backscatter would still identify the material within the container.

Backscatter is 90% effective for organics and can also detect weapons. However, you can also hide objects from backscatter. AS&E provides a black and white image, which is better quality than can be provided in colour.

Automated detection systems have too many false positives; therefore, "the man-machine interface must be definitive." The operator must be well trained and well paid for the system to be effective.

Throughput of the machine is as high as 1500 bags per hour, but the operator is limited to 600 – 800 bags per hour.

Integration

The backscatter technology is a level one method which AS&E feels could replace transmission X-rays.

The system can store or output images and has a keyboard interface for operator input. There is a capability to interface with a network in real time. Selective image transfer would make speed and storage limitations easier to handle.

Future improvements are likely to be "evolution not revolution". Could involve use of colour image, mass storage, interface changes. Discussed the use of an overlay system to combine images from backscatter and transmission on one screen. AS&E technical staff has produced such a system, but it was felt that the use of a blending wheel would add time to the process and slow the throughput.

Training

Operators are trained to see anomalies during a 90-hour computer-based training program. AS&E has criteria to grade performance. The training system allows upgrading of the images on the CD to ensure that they are current and relevant to the specific application. Selection, training and adequate pay of operators were stressed as requirements for success.

BAE Inc.

Interviewers: Ralph Herzig, Laurel Ritmiller
Interviewee: Al Rollins

Type of Business

Manufacturer of baggage handling systems

Process

- Baggage information is entered at check-in into the airline computer system.
- Computer generates a BSM number (10 digit number based on IATA guidelines).
- Baggage tag is printed (this includes BSM number, flight number, destination).
- Tag is attached to baggage and loaded onto conveyor belt.
- Baggage moves to baggage handling area for scanning.
- Laser array scanner scans bag to identify bag or re-direct bag to the right destination point.
- Baggage is loaded from destination to plane.

Comments

- Success rate of array scanner is < 85%.
- Success rate is influenced by: quality of bar code print, full display of tag.
- If a bag cannot be scanned automatically, an agent will scan the tag with a handheld scanner. Alternatively, the flight number can be manually entered in a computer terminal to identify the destination of the bag. In that case the BSM number is not used for further identification.

Integration issues

- Baggage handling systems are generally customized developments. The projects are done with airport architects. Standards include the following: 37-42 inches with a vertical of 36 inches (approx. 36 x 36 inch tunnel). Large baggage is transported on special baggage handling system that can handle >42 inch wide bags. Throat opening of conveyor belt is larger than X-ray machines. **Oversize bags are not X-rayed because of the geometrical constraints on the X-ray machine.**
- Baggage handling systems move bags at an average of 60-80 bags per minute, while X-Ray scanners process bags at approximately 40 bags per minute. The conveyor system at Heathrow, for example, operates within this range. The current maximum speeds are optimized for the particular installation, considering turning radii and environmental factors (e.g. humidity, temperature and angles). Higher operating speeds may necessitate equipment and/or infrastructure changes (e.g. high precision bearings and re-inforced structures).
- BAE's sort and control system is interfaced with the airline computer system to exchange BSM number. Additional information could be gathered from the airline reservation system but is not needed for the operation of the baggage handling system.

- BSM number is not stored permanently. Once the bags are scanned in the baggage handling area and identified by the laser array scanner the numbers are erased.
- The sort and control computer is based on Windows NT and integrates with Token Ring, TCP/IP and other network protocols. IBM compatibles are used for this purpose.
- X-ray scanner and laser array scanner are not integrated. If there is a security issue the X-ray image is used to determine problem.
- Al Rollins: Integration between X-ray machine and baggage handling system needs to be regulated and has to be security driven otherwise little progress is being made. Future includes matching everything that is loaded on the aircraft (e.g., passengers, crew, checked baggage, carry-on). Carry-on luggage would need to be processed at the boarding gate, creating a bottleneck.

Airports with BAE's baggage handling system implementation:

- Canada: Vancouver, Toronto, Montreal (e.g., terminal 1 in Toronto Air Canada)
- USA: 10 major airports including JFK, Chicago (United, AA), Miami (AA), San Juan (AA), Atlanta

Airports with partial or full integration of X-ray baggage and baggage handling system:

- JFK terminal 1, Atlanta, Heathrow terminal 3 and 4

Training

Training is provided in initial contract and is based on a train-the-trainer approach.

Maintenance is done through the Dallas office and separate from installation and training.

Ergonomics

Baggage handlers complain about height of conveyor belts for delivery of bags. Ideally, bags are delivered at shoulder or chest level to provide a safe lifting height. Physical constraints in buildings do not allow this. Baggage handlers also report problems/inefficiencies with layout/access in bag rooms.

Majority of bags are 20-30 lbs. Frequently bags reach up to 60 lbs. Baggage handlers may have to rotate baggage on conveyor belt and reach across the belt (36 inches!). Fedex and Roadway Package Services (RPS) employ personnel that orient packages. This is possible because the two organizations handle packages with smaller dimensions. Read rate would increase to >90%.

Errors

Most common error occurs when the system can't read/see tag on the baggage. This is often due to the design of the bag, items placed in tote trays, and the way in which check-in staff have attached the tag.

Barringer Technologies Inc.

Interviewers: Dan Robinson, Adrian Lee-Kwen
Interviewees:
Paul Kennedy, Sales and Support, Canadian Market
David Martinak, VP International Sales (New Jersey)

Overview of Barringer

Barringer produces trace detection systems for explosives and drugs. The demand arose in the late 1980s based on contracts from Transport Canada, Customs and FAA. Initially, trace detection technologies were based on vapour detection and were referred to as "sniffers." More recent advanced systems also detect particulates. Because electronic devices can camouflage explosives from visible detection (X-ray), trace detection provides another level of screening suspect bags.

The use of trace detection has recently gained widespread acceptance, with dramatic growth in the U.S. following the TWA incident. Barringer currently has 430 systems in U.S. airports and overseas, including Heathrow and Gatwick, and claim 75% of the market share for these systems. None of its systems are in day-to-day use in Canadian airports; however, inclusion of trace detection is anticipated on future procurement lists for Canadian airports, based on a review in progress by Transport Canada.

Products and Process

The first product was the IonScan 100 in the early 1990s. The IonScan product line has gone through several iterations, with the most recent system being the IonScan 400B. Approximate cost of IonScan 400B is US$50K-60K per unit.

The 400 and 400B utilize remote monitoring via a two-way pager to download daily data for alarms (resolved and unresolved), maintenance and system monitoring. These data indicate a false alarm rate of about 0.5%.

Barringer products are more often in use for screening of carry-on baggage than checked baggage. The use of trace detection for screening checked bags is limited by current procedures and throughput requirements. Annex 17 has a stated requirement for 100% screening of checked baggage in the future. The U.K. airports have started to use trace detection for checked bag screening.

Barringer's systems are generally used to check "suspect" bags only, as determined by X-ray screening or passenger profiling. Generally, there is one IonScan per two X-ray scanners, but it was suggested that a higher rejection ratio from the X-ray scanners could be better served by having one IonScan per X-ray scanner.

For checked bags, there is a 3- or 4-level security system. Level 1 is automated X-ray scanning, with a computer identifying suspect bags. Automated rejection occurs at a rate of approximately 30%. Level 2 is an inspection of the rejected bag image by an operator. Previously, suspect bags that contain some form of electronic device would have required locating the passenger and having them turn on the device to prove that it was functional. This doesn't preclude explosives hidden within a functional device. Level 3 is use of trace detection or CT technology to provide more information to the operator. Where CT scanning is used, trace detection may be considered level 4.

Barringer machines have a programming interface to set threshold levels and substances to detect. This is not set by the operator. There is a pass key system to lock out intrusion.

Interpretation of trace detection analyses is fully automated, resulting in an alarm if there is a substance detected. Alarms require response from an operator, who will implement a security protocol to resolve the cause of the alarm. The determination of action is based on the judgement of security personnel.

Security personnel will gather additional information to assist in resolving the alarm. This includes matching the bag to a passenger. For carry-on bags, the passenger is present. For checked bags, the passenger can be identified but is not present. Passenger profiling is a key factor in assisting security personnel with their decision.

Integration

Data output is currently not real-time, but is stored in a buffer for later download. By minimizing data output, real-time data flow could be established.

Passenger profiling and passenger-bag matching were seen as important factors to support security personnel in their judgement of scenarios.

Future "portal devices" that automate trace detection screening within the conveyor belt situation of checked bags are possible.

Training

Security personnel perform two main tasks: sample collection and alarm resolution. Training focusses on sample collection. There is no well defined method of assessing adequate performance of this task, but both Transport Canada and the FAA are working on this.

Heimann Systems

Interviewers: Dan Robinson, Ralph Hertzig
Interviewee: Chérif Rizkalla

Overview of Heimann Systems

Heimann Systems produces X-ray scanning systems for both checked and carry-on baggage, as well as metal detection gates.

At all Canadian airports, the carry-on baggage screening is performed using Heimann systems (HiScan) and checked baggage is not routinely screened. In Europe, the Heimann EDS is integrated into the checked baggage conveyor system for automated detection of explosives using X-ray technology (e.g., Nuremberg, Luten).

Products and Process (and Integration)

Mr. Rizkalla spoke of the technologies within the context of certification criteria and integration into checked baggage screening systems. The FAA's list of certification criteria for explosive detection systems (EDS) has nine categories of explosives that must be detected at a designated sensitivity. The CTX 5000 EDS by InVision (competitor) is FAA certified, but can't be integrated at typical conveyor speeds of 0.5 m/s due to the time required for a CT scan. The Heimann EDD does not meet FAA certification requirements due to a lesser detection rate, but is compatible with a conveyer speed of 0.5 m/s.

There are philosophical differences between Europe and the U.S. in their approach to baggage screening. In the U.S., a CT system (higher sensitivity, low throughput) is used in the lobby to screen selected bags (5-10% of total checked bags). In Europe, an X-ray diffraction system (lower sensitivity, high throughput) is integrated into the baggage conveyor system to check 100% of bags. Mr. Rizkalla noted a preference for the 100% screening approach. ECAC will require 100% screening prior to the year 2003. ICAO had previously advocated 100% screening for the year 2000 (Annex 17), which has not been achieved.

The system for checked baggage screening is a 3-level system. Level 1 is automatic detection based on atomic number for specific substances. The computer contains a database of atomic numbers for substances of interest. The analytical process involves peeling off layers based on detection of edges of objects. Alarms will occur if the atomic number within a layer matches or is close to that of an explosive, or if the object is too dense to analyze ("dark alarms"). Thresholds are set to determine the width of the acceptance band around an explosive atomic number. The wider the band, the more false alarms, but the greater the probability of detection. The thresholds are set by Heimann in consultation with the client.

In some systems (e.g., Nuremberg), X-ray diffraction can be used to analyze focussed areas to confirm or clear the initial automated detection. This generates a fingerprint for materials such as explosives that have crystalline chemistry. Level 2 involves transfer of an image (from X-ray transmission, or X-ray diffraction) to an operator, who must decide whether to divert the baggage or to allow it to pass. If diverted, level 3 is either the use of TEDS or calling the passenger to open the bag.

Ergonomics is specifically addressed at the University of Heidelberg for the carry-on bag screening systems. Colour coded display has been developed to assist operator identification of materials. The colour intensity is inversely proportional to human visual sensitivity to avoid fatigue and to balance visual discrimination of colour. Eye tracking measurements have been used to study operator visual behaviour. It

was noted that the tendency is to look at the passenger if operators think they see something in the display. This is not an optimal scenario, because the physical appearance of the passenger can influence the operator's judgement, which should be based on objective criteria rather than subjective appearances. The provision of a visible passenger image to the operator is also not desirable for this reason.

Integration

Defining the term "integration" is important. In European systems, integration has largely referred to physical integration of automated scanning systems into the checked baggage conveyor systems, with image transfer to an operator. In the U.S., integration has referred to data management such as computer-aided profiling (CAPS) and baggage tracking systems that link bags to passengers.

Mr. Rizkalla believes there is a problem in terms of information sharing that impedes integration.

It would be possible to scan bag tags and link with an image from the X-ray system, which could interface with the baggage handling system.

Mr. Rizkalla believes that Canada's approach to integration will likely fall somewhere between that adopted by Europe and the U.S. within the next ten years.

Training

Basic operator training is relatively simple. The recognition of images that represent explosives (IEDS) is more involved and requires some theoretical knowledge of explosives (including recognition of detonators, batteries, timers, etc.). Heimann provide computer-based training that includes explosive recognition and is capable of scoring operator performance.

Heimann also provides ongoing training that can be used to evaluate work performance. This approach is called "threat image projection" (TIP) and involves the insertion of a threat image into the image of a real passenger's scan. Operators press a button if they recognize a potential threat. In the case of a test (TIP), operators are informed that it was a test and that they recognized the image. No passenger intervention would be required. If there is no "test" response to the button press, operators must assume they have recognized a real threat and act accordingly. This helps alleviate problems associated with the requirement for long periods of vigilance with very low probability of ever seeing a threat. By providing TIP, the likelihood of detecting something is increased, which serves to help maintain operator attention as well as monitor performance.

IDS Intelligent Systems Inc.

Interviewers: Dan Robinson, Adrian Lee-Kwen
Interviewees:
Brian Rich, VP Engineering and Manufacturing, Analytical and Security Division
Andy Rybak, Executive VP

Overview of IDS

IDS manufactures a wide variety of "intelligent sensor technologies". Of relevance to airport security, are trace explosives detection systems (TEDS) that detect both vapour and particulates using GC/IMS technologies (Orion product line), and portable vapour detection (EVD product line).

Currently not in Canadian airports. Use of TEDS in airports is mandated by regulators, and has not yet been mandated by Transport Canada. It is expected that Transport Canada will soon require TEDS. Trace detection is mandated by some U.S. airports, where IDS has its Orion system implemented for screening carry-on bags. An older technology, EVD-1, has been used by the RCMP in some Canadian airports. EVD-1 was developed by Scintrex, a company acquired by IDS.

IDS did not wish to divulge its approximate market share.

Products and Process

The main IDS products of relevance to airport security include the Orion/Orion Plus explosives detection systems, the EVD-3000 handheld explosive detection unit, and the Nova walkthrough detection system.

The Orion Plus detects all ICAO taggands. Orion is in use in several airports at security checkpoints for carry-on bags, but not yet for checked bags. EVD-3000 is available but not yet approved. An earlier version, EVD-1, is used by the RCMP in Canadian airports. The Nova system is not yet in use for airports.

It is anticipated that IDS systems will be in use for checked baggage in the near future.

The bulk of security screening is done by X-ray scanning. TEDS is considered supplementary screening of bags that are identified as suspect at the X-ray stage. The Orion is placed downstream from an X-ray scanner.

Orion processes a sample within 15 to 20 seconds per bag, with a false alarm rate of approximately 0.5%. This throughput is the machine time only, and does not include the time required for operator tasks. The operator tasks include: retrieving suspect bags from the X-ray machine, delivering to the trace detector, wiping areas of the bag (handles, zippers, etc.), inserting the sample into the machine, responding to alarms, and returning the bag to the passenger.

The process of screening carry-on bags is operationally easier than checked baggage, due to the fact that the passenger is with the carry-on bag and that the checked bags are in transit on a conveyor system.

It was expressed that GC/IMS was not a good technology for automated analysis of checked baggage because of the time for analysis. An alternate technology utilizing laser scanning is being developed by IDS and will likely be available within one year. The anticipated throughput of the future laser system is approximately 600 bags/hour.

(NOTE: the IDS laser system is outlined on the TDC website at http://www.tc.gc.ca/tdc/r%26d/v9n1.htm)

Trace detection methods usually screen the baggage. Detection of explosives on the passenger is not likely with most TEDS that screen bags. The Nova walkthrough system performs TEDS in 'real-time', with an analysis time of 6-8 seconds, and can link with a video image of the passenger to allow capture once the passenger has passed through.

Integration

There is currently no collaboration between manufacturers and delivery of security services at airports is somewhat fragmented. This means there are gaps in security. Regulators who develop and specify needs and requirements must formulate requirements for integration if integration is to happen. IDS has some involvement in regulations, but feels that there is insufficient funding to do so.

In terms of data fusion, timing is an issue. Data is gathered serially, rather than in parallel, which means that information comes into the system at different times. A means of linking information is required.

The use of multiple data inputs could be useful for improving detection either by applying a boolean logic (if x and y are true, then alarm) or within a true data fusion where the alarm strength is modified at several levels. For example, if the operator obtains information from interpretation of the X-ray scan that identifies a specific item and TEDS detects a substance consistent with the X-ray scan, the probability of a correct detection has improved.

The checkpoint of the future is likely a single location for all aspects of screening.

At the moment, IDS products do not read bag tags/bar codes. Nova walkthrough TEDS already include video surveillance and could be integrated with metal detection.

Training

The most difficult and critical issue is operator training. Training focusses on the sampling technique. There is no direct means of evaluating an operator's sampling technique.

IER

Interviewer: Ralph Herzig
Interviewee: Jean Salomon, VP Business Development

Mr. Solomon indicated that IER will participate in the study only if it receives access to the report that we produce.

Mr. Salomon would likely accept being interviewed directly by a TDC representative, since from his point of view there is little value added by our interviewing him.

InVision Technologies

Interviewers: Ralph Herzig, Laurel Ritmiller
Interviewees:
David Kepniss, Product Application Engineer
Graeme Wear, Project Manager Integration
Ed Pentalari, Product Development

Type of Business

Manufacturer of X-ray systems

Technology

InVision manufactures several systems for use in airports:

- CTX 9000 can interface with a 1 m baggage handling system (BHS) and has control of 1 upstream and 3 downstream BHS. The equipment is FAA certified to handle 542 bags/h. If the equipment were not FAA rated it could process more bags. The X-ray machines produce digitized images that show 2D and 3D images. The equipment has the capability to display specific slices of the image for further analysis.
- CTX 5500 can interface with a 0.7 m BHS. Generally used at check-in by airlines (Vancouver airport).
- The CTX product lines started about 10 years ago.
- Currentiy, systems may be integrated into a BHS or may stand alone, which requires each bag to be manually loaded (CTX 5500). The move is toward the automated CTX 9000.
- The CTX 9000 is the future in Canadian airports.

Comment

IMPORTANT NOTE: If we compare throughput rate we have to rely on FAA-rated throughput and not manufacturer cited numbers. The FAA has a standard set of bags it uses for this type of tests. An FAA test does not include any wait time, processing time, etc. Numbers derived from these tests are generally higher than actual numbers in the field.

Process

All bags are X-rayed by the equipment (level 1). If a threat is identified the bag is transferred to the X-ray diffraction equipment for analysis (level 2).

If the X-ray diffraction equipment identified a threat the bag is inspected by an agent (level 3).

All information is provided at the decision point. This decision point should be as far away as possible from the scanning station (more time to make a decision, provision of more complex information, allow other bags to be processed through the scanning system to maintain flow). Frequently, X-ray machines are installed without much consideration of the process implications (time-distance/location). Design and

process layout is site specific. These systems are best integrated early in the airport design process to allow for uninterrupted baggage flow.

Older (airport) operations are less likely to be integrated; however, there is a trend toward more integration and higher throughput. The FAA is currently testing radio frequency (RF) tags to augment the tracking of passengers and bags. All information related to passenger, bag and detection result would be stored with the bag identifier.

Integration issues

InVision technologies uses open standard computer interfaces and already exchanges information between BHS and X-ray machines.

RF baggage tags will eventually be introduced at the request of the FAA (need to talk to FAA about project).

The FAA will become more stringent with the false alarm rates, which will force industry to develop new technology. Integration with X-ray diffraction machines (to identify explosives) is one way to go but the process is extremely slow (see notes for Heimann System on their approach).

Training

The company provides an extensive training program to users. Course instructors keep a log of student feedback during the course regarding successes and difficulties (e.g., tasks/functions that result in highest error rates, take longer to learn, etc.). This helps the company to refine the training program and the product's design.

Most users have used X-ray technology previously. Changing decision making/information processing rules to comply with the CTX system is more difficult with X-ray users than with completely inexperienced users (e.g., using cross sectional slices).

Ergonomics

InVision technologies uses HF expertise in the design of the equipment and display of information.

Information display:

- heavy metals (blue)
- detonators (green)
- threat (red)

The company uses FAA HF specialists as well as field agents throughout the U.S. to design equipment.

Problems

The weakest link identified by the interviewees was the equipment operator (e.g., boredom, vigilance, fatigue, inattention, professionalism, selection, training). Similar to Heimann, InVision provides the opportunity to introduce a virtual threat (TIP). This allows the management of the security personnel to test vigilance, establish performance metrics and identify areas for training. The CTX 9000 was specifically designed to be used by an operator in a remote location. (In this case it will be easy to use TIP because an operator cannot compare an actual bag with an image.)

Alarms/Decisions

The company is currently working on a technology development sponsored by the FAA. The project will involve the development of a Threat Resolution Operator Interface (TROI). It follows the ideas of wizards or agents commonly found in commercial software (e.g., Microsoft Office). This software would recommend specific steps to an operator to further analyze bags that were identified as potential threats.

InVisions products are fully automated to generate a decision (alarm/not alarm). All products are configurable depending on the site and level used (1 to 3).

Security Personnel/Operators

Ideally, the operator of the X-ray equipment would be well paid to remain in the job for a long period of time. On-the-job training and experience gathered through this process will significantly improve the analysis results.

IonTrack Instruments

Interviewers: Ralph Herzig, Laurel Ritmiller
Interviewees:
Joanne Arsenault, Director, Business Development
Paul Eisenbrand, Senior VP, Business Development

Type of Business

Manufacturer of bomb/narcotics detection systems using ion mobility trap. Samples are heated to create a vapor. Negative ions indicate explosives, positive ions indicate narcotics. For airport installation, have the explosive detection hardwired into the configuration to reduce problems in operating the equipment. U.S. Customs uses the detectors in a dual role (i.e., detection of narcotics and explosives).

Technology

IonTrack manufactures two systems:

- Vapor Tracer: portable contraband detector (narcotics and explosives).
- Itemiser: contraband detector (narcotics and explosives). Current model of Itemiser was launched in 1996. The equipment is designed to have a theoretical lifespan of 50 years.

IonTrack Instruments does not have any detectors installed at Canadian airports. Correctional Service of Canada bought several detectors for in-house use.

A new walkthrough detector is in the development phase. This system would be similar to a portal for metal detection. It includes automatic sampling and reduced operator error. The security personnel would be used only for alarm resolution. The development was done for the FAA. A maximum analysis time of 10 seconds is anticipated. For the system to work properly a passenger has to stop for a few seconds in the portal. Deployment is expected in 2001. This walkthrough system will increase the number of pieces of technology in a security screening area (e.g., implications for throughput, passenger flow, baggage flow, number of security officers), as well as the number of systems supervised by the security operators (e.g., implications for number of security officers, training, shift cycles, fatigue, cognitive overload, risk of errors).

Process

An operator takes a sample from the item to be investigated (swiping of surface). This step takes approximately 20 seconds.

Analysis of the sample takes approximately 7 seconds. This results in a maximum throughput rate of 2 passengers/minute. The system can process up to 100 passengers/hour if more than one operator is taking samples.

Integration Issues

Both Itemiser and VaporTracer are open standard interfaces (RAD port). Itemiser has MS Windows 98 installed while VaporTracer uses Windows CE.

There is one free slot for a PCMCIA card for networking using TCP/IP network protocol. Information can be downloaded over the Internet and detectors can be accessed/controlled remotely.

Training

Training on how to use the equipment and take a valid sample is 5 minutes. There is additional training required for the calibration of the instrument. The most difficult/error prone part of training is in proper sample taking.

The system does not alert the operator if the sample is poor/taken incorrectly; therefore, the operator does not receive performance feedback.

Usability Testing

Development

IonTrack Instruments conducted a significant amount of testing in the prototype stage of the equipment. For example, the Itemiser was field tested for 9 months with various law enforcement agencies, aviation organizations, etc.

The feedback from the field tests was used for the hardware and software design. Software changes are introduced frequently at the request of customers.

The Itemiser includes:

- a contact screen to retrieve information;
- no moving parts.

The detector does not require any judgment in case of an alarm. There is a context-sensitive help option throughout the system.

The detector has three levels of security that can be accessed through different passwords (i.e., everyday use, maintenance, calibration). It is up to the client to decide who has access to these levels of function.

Maintenance

There have been no reported problems with maintenance. Responsibility of the maintenance of the detectors varies from airport to airport and from airline to airline. Frequently, airlines subcontract the maintenance to security guards. Calibration of the detector has to be done on a regular basis. The equipment uses sophisticated diagnostics to identify problems and alert the operator of any corrective actions.

L3 Communications

Interviewer: Ralph Herzig
Interviewees:
Will Jowers, Director Program Management
Dr. Jim Connolly, Director of Technology

Type of Business

Manufacturer of explosive detection systems; medical devices (X-ray machines) using CAT scan technology; communications, avionics and ocean systems; microwave components; and telemetry and space instrumentation.

Technology

L3 Communication's X-ray system:

- applies a helical scan to provide 3D information of the baggage. The density field information is used to make an analysis.
- uses image density information to identify threats: threat suspicious = red, range of interest = blue, metal = green, no interest = grey.
- has been tested and approved by the FAA. Rated throughput is 482 bags/h.
- uses TIP.

The company currently has a contract with the FAA to supply a minimum of 4 and a maximum of 60 new systems to airports across the U.S.

Process

Bags are scanned in X-ray machine.

The helical scan allows the operator to "slice" any part of the image without a re-scan of the bag. This will speed up the analysis and interpretation of information. An operator with 3-4 months experience will be able to arrive at a decision within 20 seconds.

Approximately 66% of all bags pass level 1 detection. The remainder will be segregated for a second scan (level 2). This process is done automatically if integrated with the BHS.

Multiple operators are used to look at scanned bags. At the airport in Rome the equipment is installed 200 m away from the analysis/decision point (control room for 5 machines). The FAA rated throughput is 478 bags/h. According to the interviewees this rating is somewhat suspect because spacing between bags will influence rating.

Integration issues

The company provides image access through their tape facility. Each and every bag is stored on a tape (regardless of whether the bag caused an alarm). While the equipment produces images in a proprietary format a translation facility could be provided. Furthermore, images can be printed to supplement searches of bags (level 3). The equipment has a sequential tracking of bags that could be used for other purposes.

The examiner 3DX 6000 is designed to be integrated with the BHS. Conveyor belts need to be slowed down or accelerated to provide the X-ray machine with bags that are spaced (6 in) properly. Piled bags will affect the result.

Training

The company provides one week of in-class training followed by one day of training on the machine in the field. Class size is limited to 10. For the airport in Rome the company developed a short in-the-field-training course. The standard threat image projection (TIP) system can be used to monitor on-the-job performance of operators and target specific training for users.

Development

The equipment was developed in consultation with the FAA and their Human Factors (HF) specialists. The company has not had any extensive feedback on its current equipment because of the limited number of installations and limited field experience.

Thermedics Detection Inc.

Interviewers: Dan Robinson, Adrian Lee-Kwen
Interviewee: Dan Dussault, Product Line Manager, Security Products and High Speed Chemical Analyzers

Overview of Thermedics

Thermedics produces "unique solutions for chemical detection". Trace explosive detection systems (TEDS) have been produced since 1989 (EGIS 3000).

The EGIS 3000 system is in use in Europe and the U.S., but not yet in Canada. Transport Canada (TC contact is Joe Castonguay) is evaluating TEDS for use in Canadian airports, with conclusion of the project on December 17, 1999.

Products and Process

EGIS 3000 has an alarm rate of 0.1%, based on 3 million analyses in Germany. The EGIS II system was released in 1999 and is currently undergoing FAA evaluation, during which there has been 1 false alarm in 18,000 samples. It was noted that false alarms include nuisance alarms, such as might occur when trace explosive substances are legitimately present (e.g., powder residue on legitimate gun user, miner who works with explosives; nitroglycerin pills for angina, etc.).

The EGIS machine can identify what type of explosive substance is detected. The operator needs to be able to ascertain the cause of the alarm by questioning the passenger. The vast majority of alarms are resolved by the operator as a legitimate (non-threat) source of substance.

The EGIS system is used at screening points for both checked baggage and carry-on bags. The EGIS is used when the X-ray system identifies a suspect bag. This reduces the need for hand searching of suspect bags. For checked bags, where X-ray systems check 100% of bags, approximately 5% would be screened by a TEDS. EGIS is also used based on passenger profiling where a suspect individual may be identified (e.g., payment in cash, infrequent flier) or where sensitive materials cannot be X-rayed (e.g., concern of damage, diplomatic information).

It was felt that, in the future, the greatest benefit would be gained by making a smaller, faster, cheaper machine. Lowering thresholds for alarm rates (increasing sensitivity) is not needed, as the machine currently detects in the range of 300 picograms.

Integration

It was expressed that the Thermedics system is more amenable to data fusion than the competing systems because the EGIS system differentiates between substances, while competitors are a "go-no-go" alarm. This would allow communication between X-ray systems and TEDS to provide a level of redundancy in threat identification. For example, some X-ray systems claim the capability of identifying plastic explosives. This information could be provided to the TEDS operator or system. The identification of a given threat by two independent methods would raise the level of urgency.

The EGIS can hook up to an EGA monitor to display the raw data (chromatogram and tables) that were used by the machine to determine an alarm condition. This information could be provided as a real-time output or saved for later download.

In the U.K., bags that have been scanned are logged. This could be performed by the EGIS with a few software changes.

Training

Agencies formulate their own protocol for questioning passengers with a bag that tests positive for trace explosives. Thermedics provides some coaching, but doesn't get too involved because of potential liabilities.

Liability issues were brought up within the context of how much coaching is provided regarding training of operators and setting questioning protocols. In the U.S., liability is transferred to the FAA once equipment is certified. If a problem arises due to a defective machine, liability rests with Thermedics. If a problem arises due to maintenance, liability rests with the airport.

Appendix E: Vendor Interview Summaries

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American Science and Engineering

Product: X-ray technology

AS&E markets backscatter X-ray technology for "anomaly detection" for baggage, parcel, pallet, passenger, and vehicle search purposes. Currently, its products are only in airports in the Far East. North American clients include the U.S. Whitehouse, NSA, FBI and CIA. Its technology is very effective for weapon detection while dual scan transmission-based systems can only detect organics that are not well hidden. Its system can be used in conjunction with TEDS systems, as the backscatter X-ray can detect material within a sealed container.

AS&E feels that backscatter technology is superior to transmission based X-ray technology. The system can store or output images and can interface with a network in real time. Future improvements could involve using a high resolution colour image, mass storage or interface changes. Because the system is not automated, operator attention, training and motivation are significant human factors issues. AS&E has a lengthy training system for operators that focusses on anomaly detection and identification. Selection, training and adequate operator pay were stressed as requirements for success.

BAE Inc.

Product: Baggage handling systems

BAE Inc. supplies laser array scanners, belt conveyors and recirculating baggage claim systems to the airline industry. Its equipment is located in airports across North America and Europe. In Canada, its systems are in Vancouver, Toronto (Terminal 1) and Montreal.

Generally, at check-in the baggage information is entered into the airline computer system to create an identification number and tag. The baggage is loaded onto a conveyor belt and scanned by an automated laser array scanner or a hand scanner. This scanned information directs the bag to its appropriate destination to be loaded on the aircraft.

A number of integration issues were identified, including the design process, integration with X-ray systems and potential bottlenecks in the system. Human factors issues focussed on physical requirements of workers to handle the baggage from the conveyor systems, increasing the risk of over-exertion injuries.

Barringer Technologies Inc.

Product: Trace detection systems for explosives and narcotics

Barringer has 430 systems in U.S. and overseas airports, but none currently in Canada, as vapour or particulate detection systems are not mandated by Transport Canada. Its equipment is more in use for "suspect" carry-on than checked luggage as the use of trace detection is limited by current procedures and throughput requirements. There is, however, a move to use trace detection for checked bag screening (e.g., U.K. airports).

Integration issues include the fact that output data is currently not real-time, but stored in a buffer for later download. Passenger profiling and passenger-bag matching were reported to be important issues for future security advances, as well as "portal devices" that automate trace detection screening within the conveyor situation of checked bags. Human factor issues include the fact that although the interpretation of trace

detect analyses is fully automated, the alarm requires an operator response to implement a security protocol to resolve the course of the alarm. This action is determined solely on the judgment of the security personnel. This may involve gathering more information such as matching the bag to passenger, and passenger profiling. Other issues include training operators to sample baggage correctly and respond appropriately to alarms. Currently there is no defined method to assess the operator's sampling technique.

Heimann Systems

Product: X-ray scanning system and metal detection gates

Heimann X-ray systems are used for both checked and carry-on baggage. In Canada, all carry-on baggage screening is performed using Heimann systems, and checked baggage is not routinely screened. A multi-level screening process is determined in conjunction with each client.

Potential integration issues include problems with sharing information between systems, and varying speeds of each device. Heimann involves TIP technology to assess operators routinely. It reports human factors have been considered in the development of the screening systems. Issues include operator decision making when a threat has been detected.

IDS Intelligent Systems Inc.

Product: Trace explosives and vapour detection systems

IDS manufactures a variety of "intelligent sensor technologies" for baggage and passengers, including portable and walkthrough systems. Its trace explosives detection systems (TEDS) are currently not in Canadian airports, as the use of TEDS has not yet been mandated by Transport. Canada. Portable vapour detection systems are used by the RCMP in some Canadian airports.

Integration issues include the fact that there is currently no collaboration between manufacturers, which makes connecting the various security systems difficult. A means of linking data that is collected independently and at different security checkpoints will be required (e.g., matching the security scans of checked and carry-on bags to a specific passenger). Integration may lead to a single check-in location for all aspects of screening. The walkthrough TEDS system may be integrated with metal detection and currently includes video surveillance. Human factors issues include training of operators to sample baggage correctly and respond appropriately to alarms. Currently there is no defined method to assess the operator's sampling technique.

InVision Technologies

Product: X-ray systems, X-ray diffraction

InVision Technologies supplies X-ray equipment for level 1 screening, as well as X-ray diffraction equipment for level 2 screening. Their equipment is located in some Canadian airports, and InVision expects that its new design, the CTX 9000, is the future model to be integrated in Canada.

Integration issues include the physical integration of its equipment with baggage handling systems for uninterrupted flow. In the U.S., the trend appears to be toward radio-frequency tags to increase passenger and baggage tracking. This would require integration of equipment throughout the process. Human factors

issues involve training with the X-ray diffraction equipment and requiring operators to sample cross-sectional slices of the image for threat detection. Current research and development is focussed on a Threat Resolution Operator Interface (TROI) to prompt operators through the software screening process.

IonTrack Instruments

Product: Explosives and narcotics detection systems

IonTrack Instruments systems are based on ion mobility to detect explosives and narcotics in airports, correctional facilities, and educational facilities. Some of its equipment may serve a dual role (e.g., U.S. Customs). In Canada, its systems are currently used by Correction Services Canada. A new walkthrough system is in the development phase.

Integration issues include physical integration of its systems with other screening systems, and an anticipated future requirement to sample each piece of baggage, resulting in throughput issues.

IonTrack does not anticipate hardware or software issues with its detection systems. Human factors issues include the fact that the system does not indicate when the sample taken by the operator is not adequate. The new walkthrough system will increase the amount of equipment in an area, as well as increase the information processing requirements of the user.

L3 Communications

Product: Explosives detection and X-ray technology

L3 Communications supplies X-ray technology that applies a helical scan to provide 3D information of the baggage. The company has products in Europe and North America, and reports that it has a contract to expand their product across U.S. airports.

Integration issues focus on the speed of the X-ray system, which is slower than current baggage handling systems. Human factors issues include operator training on how to operate the device, make decisions about how to sample the image, and then make decisions about the results of the analysis. TIP can be used to monitor operator performance and target specific training for users.

Perkin Elmer Instruments

Product: Security equipment, primarily X-ray and explosives detection

Perkin Elmer has recently expanded its portfolio to include Level 1 and 2 screening equipment with the acquisition of Vivid Technologies. Perkin Elmer equipment is currently in a number of Canadian airports.

Integration issues include potential problems with different operating systems among vendors, and the combination of new and old systems resulting in inconsistencies in hardware and software requirements. On a number of occasions, Perkin Elmer has teamed with other vendors to provide integrated security and baggage handling systems. It believes that the acquisition of Vivid Technologies may indicate a trend in the consolidation of manufacturers. Human factors issues include a trend toward the operator becoming less important in the system, only responding to alarms when they occur.

Thermedics Detection Inc.
Product: Trace explosives detection systems

Thermedics Detection Inc. TEDS are in use in the U.S. and Europe, but not yet in Canada. Its systems can identify what type of explosive substance has been detected and the operator must determine the cause of the alarm by questioning the passenger. Its systems are used at screening points for both checked and carry-on baggage, and when X-ray analysis identifies a suspect bag, reducing the need for hand searching.

Because its system differentiates between substances rather than only presenting a general alarm, Thermedics feels its system will be more flexible for data fusion. This would allow communication between X-ray systems and TEDS to provide a level of redundancy in threat identification. Human factor issues include how the operator interviews the passenger when an alarm occurs. Current training and operating procedures are determined by each location.

Appendix F: Organization Interview Guide

General

1. Can you provide an overview of your organization, its mandate and the services it provides?
2. What is your role within your organization?
3. What elements of air transport security fall within your (organization's) jurisdiction?
4. Are you aware of any studies that have been conducted on trends in:
    - airport security
    - security screening equipment (including potential for integrating different types of equipment)
    - explosive or weapon detection
    - passenger facilitation

Airport and airline operations

5. What are current trends in passenger facilitation?
    - passenger identification
    - passenger screening
    - carry-on baggage screening
    - ticket/boarding pass screening
    - baggage match
    - other
6. What factors are driving these trends? What are the impacts of new technology (e.g. Smart Cards, electronic ticketing, new methods of detection)?
7. How do these current trends affect passenger facilitation in terms of efficiency/safety/cost-effectiveness? What are appropriate measures of these?
8. What is the most important aspect of security equipment and integration from the public's perspective?

Security Industry

9. Who sets the standards for the security industry? If your organization sets standards, could we obtain documentation that describes these standards? Who ensures compliance with these standards?
10. Which organizations are leaders in security equipment and why?
11. In what ways is security equipment changing?
12. What measures is the industry undertaking to introduce new equipment?
13. What is the most important aspect of security equipment from screening personnel's perspective?
14. What measures is the industry undertaking to ensure the compatibility of security equipment from different manufacturers? Is this regulated? By whom?
15. What is the potential for integrating different types of equipment? What problems does the integration present? What opportunities?

Appendix G: Airport Interview Guide

Screening Area Design

Screening Points

- Passenger screening metal detectors (portal, X-ray, wand)
- Carry-on baggage screening (explosive residue)
- Checked baggage and cargo screening
- Ticket and boarding pass screening

Physical Layout

- Designed passenger throughput rate
- Age of facility
- Process aides (e.g., lights, barriers, etc.)
- Blueprint of screening points and areas designated for special requirements (e.g., inspection of baggage, special needs passengers, groups)
- Work area design (e.g., lighting, air conditioning, noise control, etc.)
- Process flow – logical and physical sequence of movement of baggage and passengers through security screening process (e.g., location of bottlenecks, points of communication, decision points)
- Queuing strategies (e.g., changes to process, use of process aids, etc. with changing passenger volume)

Staffing for Screening Process

- Number of workers per screening point
- Shift structure: length of shift, shift cycle (e.g., 5 days per week, 4 days on/4 days off), full-time or part time staff, shift transition (e.g., time, overlap or switch)
- Do workers rotate through job positions?
- Worker profile (e.g., height, fitness, color blindness, language, etc.)
- Equipment training
- Security training (e.g., critical incident, effective communications, profiling passengers) – company versus provincial (state) or federal
- Basic education
- Employee selection criteria
- Structure of security organization (education/experience requirements for different security officer levels)
- Main decisions needed to be made by security staff (are there formalized policies on when supervisors are to be called?)

Security Screening Process

- Have you had security breaches in the past? How have these happened? What do you identify as the root cause of the breach (e.g., inadequate training, equipment malfunction, poor decision-making by security staff, inadequate security systems)? [This is a very sensitive question to ask a director of security. It should be worded more along the lines of "In your experience, what have been the root causes of breaches of security (e.g., inadequate training, etc.)?"]
- In the past, with renovations or technology upgrades, have there been technologies which have not worked and been discarded?
- Can you identify special case scenarios that require changes in procedure (e.g., a special needs passenger, identified threat, high risk targets)? What is the standard protocol for handling these scenarios?
- How does security staff identify other personnel entering secure areas (e.g., cleaning staff, airport employees, pilots/flight attendants, emergency personnel)?
- Do screening equipment manufacturers adequately consider security officer capabilities, experience and training as part of their design process?
- Do screening equipment manufacturers, either individually or through an industry association, work with airport groups to address user and operational environment requirements?
- How many passengers (on average) do you stop and search?
- What are the common false alarms? Could you provide a breakdown?
- What type of threats or banned items can your security system really detect?

Appendix H: Airport Interview Notes

Security Screening Process

Baggage

- Checked in at counter
- Moved to basement of airport
- X-rayed in basement (no further inspection done under standard security threat conditions)
- Transported to plane

Note: All packages are screened at check-in (process for Canadian and international flights is the same). The U.S. conducts positive bag matching after customs. Area between customs and X-ray portal would be able to accommodate X-ray machine for baggage scans. International airlines have the option to use their own baggage scanners to scan bags prior to check-in. X-ray machines are not under control of Transport Canada. International airlines that conduct this type of check at Vancouver International Airport include: Malaysian, Singapore, Korean and Japan Airlines.

All bags use tags with bar code for delivery and identification.

Travelers

- Documents (ticket and passport check for international flights) verified at check-in
- Hand baggage and traveller checked with X-ray portal and small bag X-ray machine.
  - this step may include search with wand to detect metal
  - this step includes ticket check
- Traveller checked at gate and ticket matched

VIP Processing

- VIPs are received on airfield that had been previously cleared.
- RCMP personnel receive VIPs, guiding them to their final destination.

Security Arrangement

Personnel

- All personnel at the X-ray portals are paid by the airlines.
- Transport Canada certifies personnel to work at portals.
- RCMP cannot intervene at portals.

Equipment Specs

Nav Canada (or subcontractor) specifies the type of equipment used for inspection. The equipment specs in Canada and the U.S. are standardized.

X-ray portal
Crown Technical Systems Inc.

X-ray hand baggage
AM-SCAN 6040 Heimann

Space

Transport Canada and Nav Canada determine what type of equipment is to be used at the airports. These organizations determine the environmental standards (i.e., shielding) as well. The airport authority accommodates the prescribed equipment.

Logistics

- Airport Authorities use Secure Guard to monitor buildings, vehicles.
- Airline-subcontracted security personnel monitors activity in portal area.
- RCMP and airport authority security personnel monitor activity inside and outside the airport.
- There are links between Airport Security, RCMP and portal personnel.

Alert Levels

There are four security alert levels at the airport:

Basic: Normal operating activity with random checks.

Level 1: Check each and every passenger and bag.

Level 2: Close access points, narrow access to airport location, check vehicles, etc.

Level 3: Only authorized personnel (i.e., passengers with tickets, airport staff and airline personnel) are to enter airport, all vehicles are searched.

Example: Gulf War resulted in Level 1 alert.

Canada Customs

Passengers entering Canada Customs area must have undergone equal or better screening process.

Unattended Baggage

- Any baggage left unattended for more than 20 minutes is searched.
- Unattended baggage is an airport issue and is dealt with by the airport authorities.
- Security personnel at the airport try to identify owner.
- Bomb detection devices and dogs used as appropriate.
- Unattended bags are generally not observed through video surveillance.

Appendix I: Interviews

Security Organization Interviews

Several organizations were interviewed to determine what they believe are the key elements in the integration of technological screening equipment and processes. Transport Canada contends that integration initiatives cannot be pursued while only dealing with the technology issues. Human factors will have a significant impact on any integration initiative and may detract from projected benefits of the proposed systems or processes if not dealt with in the early stages. The consensus is that integration is needed and will be achieved in the next few years; however, human factor/ergonomic issues are critical to the initiative and should be addressed hand-in-hand with technology enhancements.

A common theme for interviewees who operate within the airport environment is how to optimize security operations while moving passengers and baggage as expeditiously as possible. Also, all those interviewed feel that security enhancements, especially those related to technology and its intrinsic costs, must be based on a realistic threat and risk process. In other words, enhancements or integration should not be undertaken, unless demonstrably needed to protect passengers and public as well as maintain current passenger/baggage flowthrough rates.

Interviewees noted that they are not aware of a demonstrably significant threat/risk environment in Canada at this time to warrant large outlays of funds for integration or screening enhancement objectives. Although it was generally agreed that the results of integration would be positive, the initiative needs to be supported by a formalized threat and risk process that identifies why, or to what extent, the costs of integration are justified. It is our understanding that a threat, risk and impact assessment process should be undertaken prior to expenditures which may have a significant impact on air carriers as well as airports.

Interview comments are divided into three main categories: People (Human Factors), Process and Technology.

Royal Canadian Mounted Police, Canadian Bomb Data Center, Federal Bureau of Investigation

People

The contacts interviewed indicated that Security Officer (SO) testing needs to be enhanced as part of the hiring process in order to verify that each SO possesses an acceptable level of basic cognitive skills. Enhanced integration means an increased level of "officer assists". Some security officers will likely find it more difficult to process the nature and amount of information presented to them. There will be a need for simple, helpful technological assists that provide the SO with additional plain-language information as well as various action options.

A major threat to ensuring maximum protection through integration of technology is the human element. It was recommended that there be increased background checks of security personnel applicants. More intensive training is needed, especially with respect to interaction with technology systems. It was also mentioned that there needs to be a greater emphasis on security principles and concepts in security officer training modules, in addition to the emphasis on teaching "people skills", such as anger dissolution, to security personnel. The most glaring differences between North America and Europe in the entire airport screening process are accreditation, training and recertification of airport security personnel.

Process

There will be a requirement to design and exercise more passenger "processing" than at present. This might be achieved with simple queuing techniques but may require more staff on the receiving side of the line to ensure the orderly flow of passengers is maximized. More direction or signage will be needed to maximize passenger preparedness for the screening process. In the area of overall security, the point was made that there should be an increased use of penetration testing as part of an ongoing preparedness program.

The RCMP contact was quick to point out that the RCMP is not in the business of air traveller screening, but is asked from time to time to perform various types of screening, from suspected contraband to persons.

A combination of integrated screening technologies will enhance detection of contraband items and can likely be accomplished without a reduction in current passenger throughput. Security personnel issues as noted above need to be addressed, however, in order to benefit from the enhancement/integration process.

Integration issues should also be included in airport planning processes, as they will rarely be effectively implemented at a later date.

Technology

It was questioned that if integration is the process by which we maximize screening efficiencies, why not include the photographing of each person going through the screening line, integrated with a facial recognition technology. This would link the image of the person with the inspection process.

Interviewees mentioned that more thought needs to be given as to how the security process will support and back up technology integration. The RCMP contact felt that, in lieu of strip searches, the most effective means of screening persons for possession of weapons, contraband or explosives is the X-ray backscatter technology. The RCMP has worked with this technology for the past three or four years and, human rights and privacy notwithstanding, it is most effective method to look for concealed items. The integration of several technologies and screening methodologies would be required to maximize the detection of contraband items.

In the area of screening items for explosives, the contact suggested that technologies which best compliment one another will most likely be based on different physical and chemical phenomena, and through integration, will prove the most effective in combination with the physical screening process. For instance, quadruple resonance spectrometry is very good at detecting plastic explosives but is much less effective in detecting conventional explosive slurries and emulsions. The latter can be detected using enhanced X-ray techniques, which is less effective in detecting C4 and PETN products. Trace particle and vapour detection can be used to complement both of these systems.

Air Transportation Security Corporation

People

Our contact could not foresee a time when the human security element could be removed or even decreased as a result of technological integration. The premise here is that equipment gives the operator the tools to make decisions; it does not make decisions itself. Motivation of security officers at screening lines is a critical issue that can have a serious impact on any system/process solution.

Process

Design of approaches to screening lines needs more attention in Canada. Although throughput can only be approximated without conducting a detailed study, it is estimated approximately 250 passengers per hour with current systems/processes in place. There is too much focus at present on the travelling public and not enough on airport workers, vendors, trade persons, etc. Further study on how process effectiveness can be maximized from both technology and human resources perspectives is needed.

Technology

The driving factor for enhanced technology is believed to be government monitoring of security and safety in the transportation sector. Integration can be accomplished as long as manufacturers are involved in planning process. Our contact felt that manufacturers are normally responsive to industry needs.

The expanded use of TIPS will likely require more human resources to be involved in the process. Efforts need to be expanded with respect to "operator assists". A lot of work has been done but more is needed. Operator assists are not currently as effective for carry-on baggage as they are for checked baggage. In-depth work needs to be completed on Cost-versus-Effectiveness of any proposed integration project.

Airport Interviews

This section presents comments based on interviews and observations from a number of airports within Canada and the United States. The majority of interviews included a discussion of "cost versus threat" or "cost versus risk" issues. In most cases the interviewees could not point to a document or situation that would, today, support significant expenditures in capital/operating and maintenance dollars for large security technology integration projects. Their question, paraphrased, is "What is the foundation for this level of expenditure and is it best spent in the area of technology, bearing in mind what is already in place?"

One method of identifying and supporting the need for this type of project is through the Threat, Risk and Impact Assessment (TRIA) process. According to our information, this has not been completed with respect to supporting a case for a large-scale integration of security screening technology. It is commonly accepted that the TRIA provides the basic information, support and justification for normal (day-to-day) and enhanced levels of security at any site or operation. It not only identifies what inherent protections are in place to combat threats and mitigate risk, but identifies vulnerabilities that need to be reduced or eliminated during times when the threats/risks are greater.

London Heathrow International Airport

People

The prevailing position on security personnel was that, while there is a need for more equipment, the security officers make the most positive difference, particularly their ability to recognize suspicious behaviour. This may be achieved through a hiring seasoned staff with years of experience. The point was also made that potential threats may also come from airport workers, not just passengers.

Process

Pedestrian "lanes" using a post and rail configuration are used to channel passengers as they approach the screening line. The high level of interaction between screening personnel and passengers lining up to be screened was primarily a means for security personnel to pre-screen passengers. A police officer in the terminal area commented that this was an inexpensive, effective way to screen for suspicious behaviour. It was also noted that all screening personnel wore gloves.

Technology

There were no metal detecting wands at the screening point, although all passengers who triggered the metal detector portal at either of the two screening lines were hand searched. This search was performed in the open and there were no other signs of increased security at the airport during this time.

Miami International Airport

People

A recent study of screening line environmental issues, performed on behalf of the FAA by Booz, Allen & Hamilton Inc., reveals that security officers have a greater sense of pride in their work due to the high-tech feel of their environment. It was also noted that security officers who operate the X-ray screening process and view the X-ray images work much more effectively if isolated from public view.

The positioning of the security supervisor's console is critical. If done correctly, as in Concourse G, the supervisor has an excellent overview of the secure side of the screening line and its operation. Passenger processing would be further enhanced if a security officer/greeter were placed in front of the screening line to direct passengers who might not be familiar with the process.

Miami requires that security officers wear the same style uniform regardless of the company or air carrier that contracted them to staff and operate the screening line. It was indicated that there may be a greater threat to civil aviation from airport and air carrier employees, rather than the travelling public.

Process

There was a significant amount of space on public terminal side of screening lines to allow for queuing, although there were no demarcation barriers or pedestrian lanes at these specific locations. On the date of our visit, there was one police officer stationed near the screening line viewing the screening process. Passenger flowthrough appeared higher than at other screening points because of the efficiency of design.

The technical integration of the metal detector portal and X-ray tunnel offered the greatest opportunity for enhancing the screening process. Unconfirmed reports indicate that passenger flowthrough rate is approximately 30% higher at the Concourse G screening point than at older style screening lines. In addition, security officers are generally very pleased with the design of the screening line. Development of screening line standards, layouts and configurations is critical.

Miami is in the process of defining specific standards that will include all environmental and design issues. Signage explaining who actually operates the screening line has proven to be very valuable in educating the travelling public as to who is responsible for this function (i.e., not the airport).

Passengers moving from Concourse G into the general terminal area go through a set of glass doors, which are motion activated and will automatically open to allow egress from the concourse. Persons who approach these doors from the terminal side are detected and subjected to automated verbal warnings directing them to move away from the doors. At this moment an alarm is sounded at the nearby security supervisor's console and visual observation of the person commences. The video recording system also begins to loop the video image of the individual until he or she is manually cleared by security staff.

If the person attempts to enter the concourse, perhaps when the doors open to allow passenger exit, a security officer will intervene.

Technology

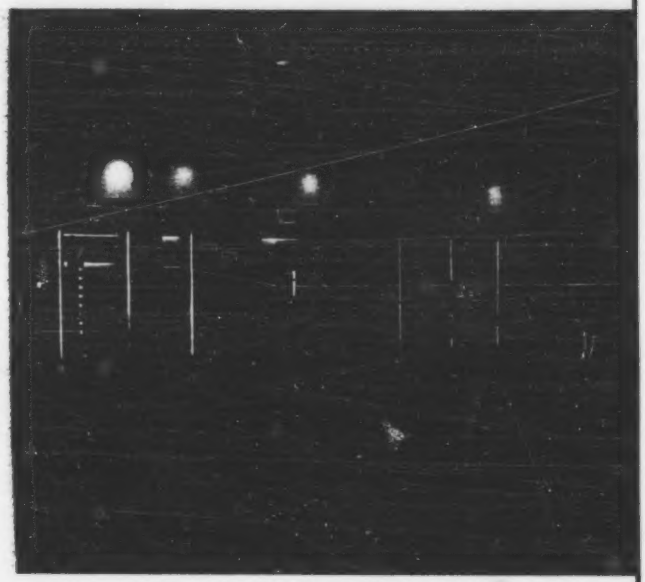
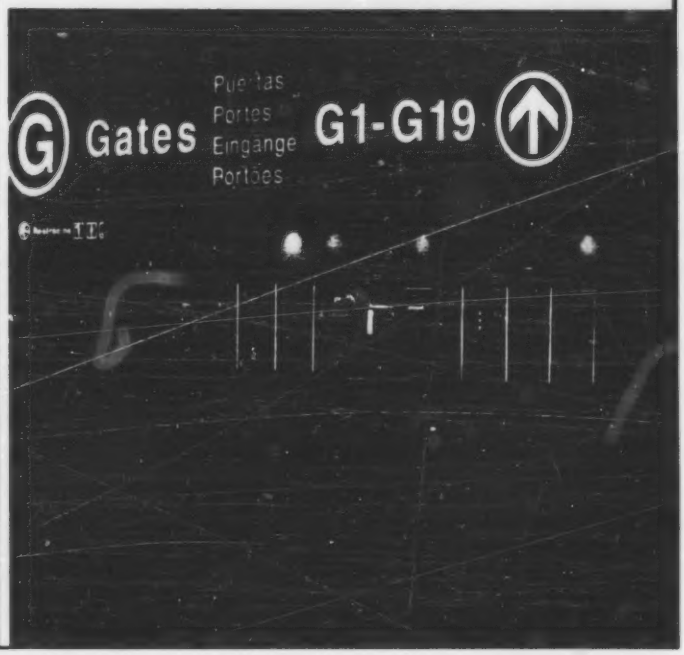
Miami has an excellent design for approaches to screening lines through the use of lighting and signage, primarily using illuminated signage around the individual screening points to indicate which were open. The screening line at Concourse G features the QControl System manufactured and installed by ADT, and designed to be built around existing screening equipment. It is our understanding that the FAA can provide funding for installations that are part of airport screening upgrades, but not for actual screening equipment such as X-ray machines, metal detector walkthroughs (portals) and hand-held wands. ADT's product utilizes existing equipment and, with some interface technology, the result is as depicted in the photographs taken at MIA during our visit.

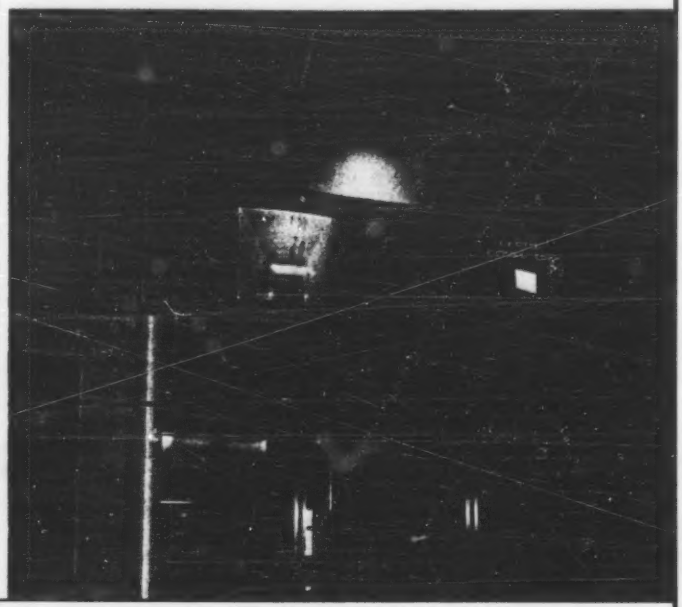
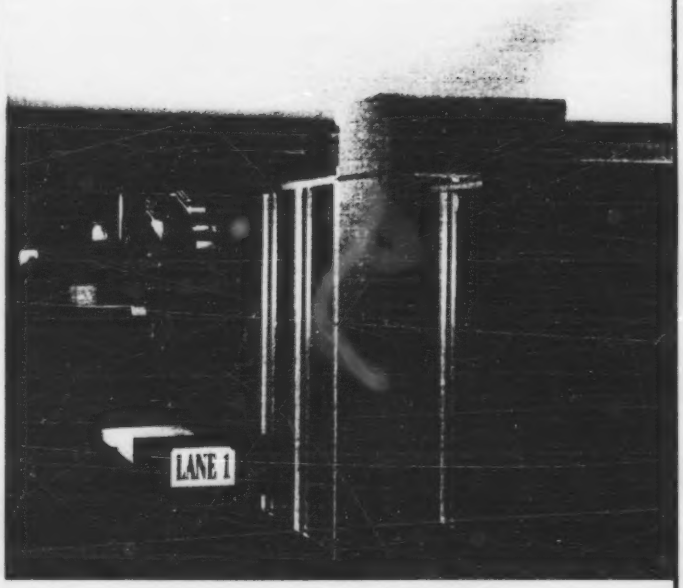
As shown in photographs 1 and 2 the approach area to the screening line is quite large and virtually devoid of any obstacles, allowing passengers to look ahead and see which portals are open. The area lighting above and immediately around the screening area appears less intense than in the general terminal, which tends to make the line stand out, as do the bright colors used to line the edges of the walkthrough portals.

There are several closed-circuit video (CCV) monitors installed above the line of portals as shown in photograph 3. These monitors display educational and awareness messages, and attract the attention of persons approaching as well as those standing at the screening line. Once at the screening line, a person takes a plastic container from a dispenser built into the wall partition immediately to the right of the X-ray machine feed belt. All items that may activate the walkthrough are deposited in the container and placed on the X-ray machine feed belt along with carry-on baggage. Closed-circuit video cameras record each person as belongings are placed on the belt.

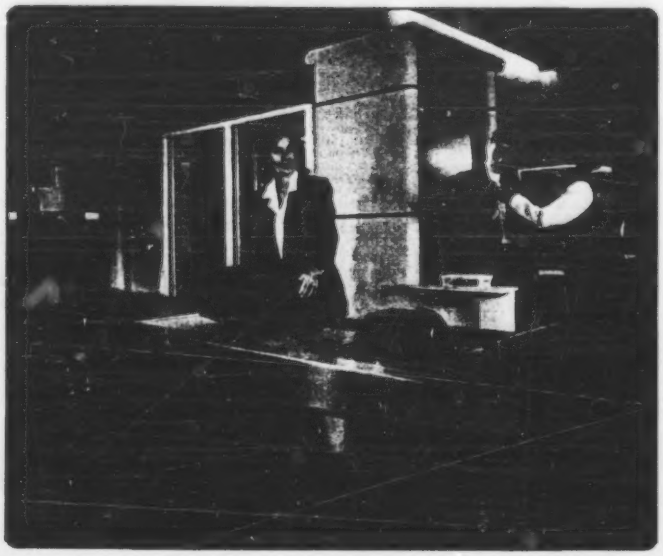
After passing through the first metal detecting walkthrough, passengers see a second walkthrough in front of them on the left. Green strip lights, similar to the type mounted on the first portal, remain illuminated unless the person has activated the first walkthrough, setting off an alarm. If this happens, the lighting strip around the second portal will immediately show red to direct the person to proceed through the secondary check. A security officer stands in the area by the second portal to ensure persons proceed as directed.

A CCV camera also records the image of passengers retrieving their belongings from the other side of the X-ray tunnel. A security officer retrieves the empty plastic container and feeds it back into the dispenser from the secure side of the screening line. Miami has installed metal detector portals and X-ray equipment to screen airport employees accessing restricted areas. Enhanced access control requirements have also been put in place for MIA employees accessing/exiting restricted airport areas. Security employees are required to carry their personal belongings in clear plastic backpacks or fanny packs if they intend to access restricted areas.

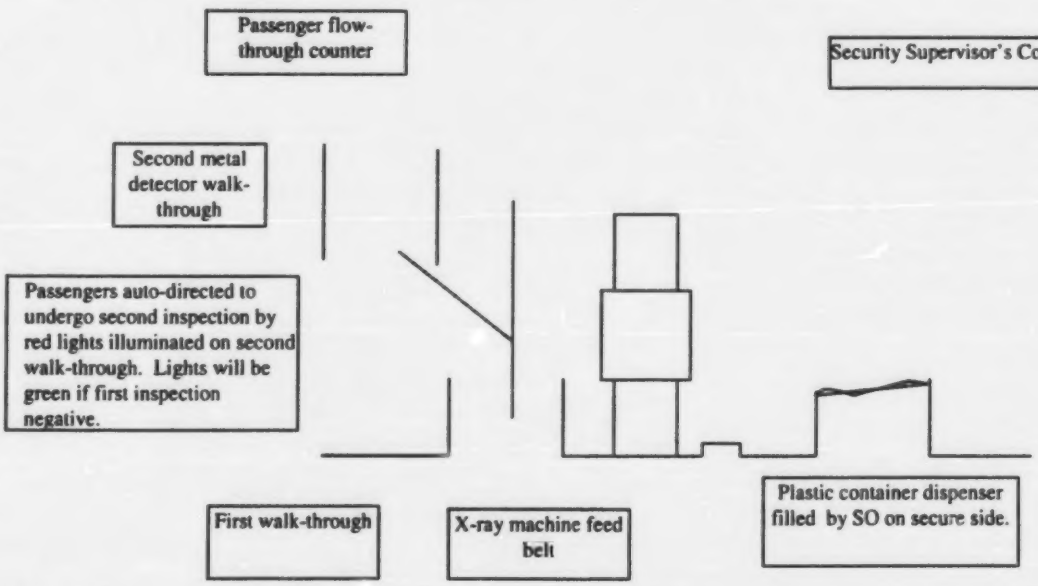
Item	*Detail*	*Photograph*
1	ADT QControl System passenger screening line at Concourse G. Active metal detector walkthroughs are illuminated with green strip lighting; inactive or closed walkthroughs are illuminated in red light. The area immediately in front of the screening line is open and quite large, allowing passengers to look ahead and see which screening stations are open.	
2	Video monitors above the walkthroughs perform both an informational and educational role for persons approaching the screening line. The blue vertical lighting shown at far right of photograph illuminates an oversized glass swinging door used to bring wheelchairs, etc., through the screening line. This door is always secured and must be opened by a Security Officer standing on the concourse side of the screening line. Wand and hand searches are conducted in these situations.	

Item	*Detail*	*Photograph*
3	The video monitor on the left displays an image of passengers placing their carry-on baggage and metallic objects on the X-ray tunnel feed belt. The video monitor on the right displays a message respecting laptop computers. The security messaging process used by Miami airport is very simple. For example, one message depicts a handgun in a circle with a line drawn through it.	
4	Photograph of screening line from concourse (secure) side. Passengers who activate the first walkthrough are automatically directed towards the second walkthrough. First walkthrough Second walkthrough	

Item	*Detail*	*Photograph*
5	The monitor on the left side of the console displays the image of the passenger exit lane, which is located immediately adjacent to the screening line. The exit lane features automated doors that open on approach of a passenger leaving the concourse. Persons approaching these doors from the terminal (non-secure) side receive automated verbal warnings to stop and move back from the doors. Should a person not move back from the exit door, an alarm sounds at the supervisor's console and the video image of the person is continually looped (displayed) for the supervisor's attention.	

Item	*Detail*	*Photograph*
6	Passengers are videotaped both placing and retrieving the carry-on baggage and personal items such as watches, cellular telephones, etc., they have placed in a plastic receptacle and passed through the X-ray tunnel. One unexpected benefit from this process is that claims for missing items, such as cellular telephones, have dropped to almost zero at this screening point.	

General Screening Line Layout


Passenger flow-through counter
Security Supervisor's Console
Second metal detector walk-through
Passengers auto-directed to undergo second inspection by red lights illuminated on second walk-through. Lights will be green if first inspection negative.
First walk-through
X-ray machine feed belt
Plastic container dispenser filled by SO on secure side.

Principal Observations

From discussions with airport personnel, the following points were offered as being critical in enhancing security and flowthrough at passenger screening lines:

- Increase use of lighting and signage leading up to and at the screening line (e.g., the ADT QControl product);
- Use more international symbols in signs rather than words;
- Emphasize environmental issues such as lighting and available space for both sides of the screening line;
- Develop standardized, detailed screening line designs;
- Train security officers to be "greeters" as well as monitors;
- Place a greeter in the public area in front of the screening line;
- Develop and use motivational training for security officers employed at screening lines.

The screening line environment and operation of points such as Concourse G versus those concourses not equipped with the ADT system is visually quite dramatic. MIA is an extremely busy airport where a large portion of its travellers do not speak English as their first language. Passengers as well as meeters and greeters proceeding into Concourse G are better prepared by the time they arrive at the screening line and can be processed in less time due to the proactive, efficient design. During the time spent observing the operation of the line, there was much less confusion on the part of the passengers, which translates to less stress on the security officers. This in turn feeds back to the passengers as a much more pleasant experience than observed at the Concourse C screening line one day later.

Security personnel advise that the ADT system makes a significant difference and should be considered a success as well as a current best practice.

Chicago O'Hare Airport

Despite our best efforts to contact screeners at this facility, we did not receive the cooperation we originally anticipated. Consequently, we do not have relevant information on the Chicago O'Hare Airport.

Greater Toronto Airport Authority

People

The GTAA contact emphasized that the basic hiring process and minimal incumbent attributes/capabilities as well as basic screener training and updating would need to be reviewed and likely increased or enhanced. Enhanced integration should be complemented with increased attention to ongoing staffing and process issues such as more frequent rotation of security staff. The requirement for technical service persons to be permanently on-site would also increase with a higher level of integration.

Process

As far as the GTAA is concerned, any delay in passenger movement is not justified except in extreme circumstances. This has major implications for equipment integration, particularly in the importance for any initiative not to reduce passenger processing speed. The contact also mentioned that the GTAA would not be responsible for the screening process, which would have a potentially significant impact on airport operations by increasing floor space requirements to accommodate equipment or overall screening operations, or slowing down passenger processing.

Technology

The GTAA contact stated clearly that he does not feel a significant threat/risk has been identified within Canada to warrant large outlays of funds for integration or screening enhancement objectives at this time. The contact did not contend that the results of integration would not be positive, only that it is not based a solid foundation at this time. The contact seemed to feel that a threat and risk assessment process would be of value and should be completed prior to expenditures that may significantly affect air carriers as well as airports.

The GTAA had some pertinent questions: What does integration entail? Will the system alarm independently of the screener? Will the alarm be local to the inspection point as well as at the airport's monitoring and control centre? If so, what are the protocols for dispatching police, canines, security personnel and terminal staff to the inspection location?

From time spent with the GTAA, it was clear that it feels the process at present meets the identified/demonstrated threat and that integration initiatives should be based on positive outcomes for all stakeholders.

Vancouver Airport Authority

Process

Any baggage left unattended for more than 20 minutes is searched, and any unattended baggage is an airport issue, to be dealt with by the airport authorities. Bomb detection devices and dogs are used as appropriate. Unattended bags are generally not observed through video surveillance.

There are four general security alert levels at the airport:

Basic: Normal operating activity with random checks.

Level 1: Check each and every passenger and bag.

Level 2: Close access points, narrow access to airport location, check vehicles, etc.

Level 3: Only authorized personnel (i.e., passengers with tickets, airport staff and airline personnel) are to enter airport, all vehicles are searched.

Example: Heightened security during the Gulf War resulted in a Level 1 alert.

Technology

The U.S. conducts positive bag matching after customs, and the area between customs and the X-ray portal would be able to accommodate an X-ray machine for baggage scans. International airlines have the option to use their own baggage scanners to scan bags prior to check-in. These X-ray machines are not under the control of Transport Canada. International airlines that conduct this type of check at Vancouver International Airport include: Malaysian, Singapore, Korean and Japan Airlines.

Appendix J: Organization Interview Summary

With respect to integration of passenger/baggage screening equipment and processes, airport operators and air carriers suggest the following items are important and potentially critical issues:

- Integration initiatives should be based on the principles of threat and risk, and implemented based on positive outcomes for all stakeholders.
- In this area, enhancements would be costly and likely require substantial increase in space requirements. This directly and significantly affects airport space requirements.
- Basic hiring processes and minimal incumbent attributes/capabilities would have to be reviewed and possibly enhanced.
- Basic security personnel training and updating would need to be reviewed and likely increased/enhanced.
- Enhanced integration would mean more attention to ongoing staffing and process issues such as more frequent rotation of security staff.
- What does integration entail? Will the system alarm independently of the operator? Will alarms be local at the inspection point as well as at the airport's monitoring and control centre? If so, what are the protocols for dispatching police, canines, security personnel and terminal staff to the inspection location?
- The requirement for technical service personnel to be permanently on site would increase with the level of integration.
- Allowing "meeters and greeters" through the screening line would complicate the passenger flow process, increase stress on security personnel and potentially increase the level of risk to the travelling public.
- Have there been any financial projections with respect to an integration initiative?
- Who will be responsible for higher capital and costs?
- Cost-effectiveness and throughput are key considerations from the airline company perspective.
- From the perspective of a screener, important aspects are the utility, effectiveness and safety (X-rays) of systems.
- From a passenger perspective, the important aspect is confidence in the system. Passengers would not be willing to be inconvenienced and delayed, especially if they do not understand the need for enhanced security. A communications plan would be needed to educate passengers without raising "big brother issues".
- Ineffectiveness and human error associated with the "boredom level" inherent with manual visual detection would be reduced.

- Integration should provide a greater overall comfort level on the part of operators, screeners and passengers; however, each group needs to have early input in the design and application process.

As briefly noted previously, integration efforts should include the threat, risk and impact process as a founding component of an overall strategic passenger/baggage-screening plan. This plan should also consider technologies that are currently not used, such as photographic identification and analysis of travellers as they pass through screening or other critical points in the processing chain. A careful review of the travelling public's reaction to this technology would need to be conducted, although at least one interviewee felt that if communicated correctly, it would be an acceptable security enhancement. Recent developments in facial recognition technology could also be integrated with this process and function well in the identification of the criminal or terrorist element.